POWER

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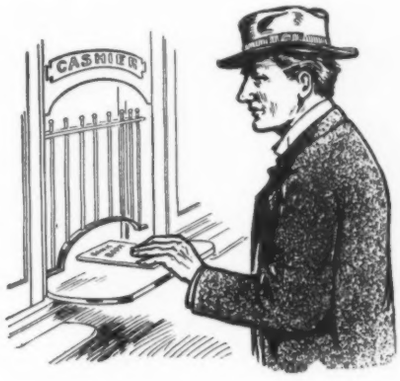
Candid Chats



The Forehanded Man

Ever save any money? Ever start down to the Home Savings Bank and, thrusting your bankbook through the paying teller's window, say: "Here we are again, Caleb"?

You never did this thing? Well, you've plenty of company. But you always *meant* to? Sure, until the time came to do it. You banked on "futures." That was all you really did bank, was it not?

Right this minute, perhaps, you are tucking away a twenty because your last spring's suit is plenty good enough—until next spring gets here. Then you buy a new one with your contemplated savings.

And you see where you can save twenty-five more this summer by sticking around home on this year's vacation, and just taking day-trips. It's a tight little sum you're piling up already—in your mind.

Then there's Mrs. Engineer. It ought to be easy, any time, for her to pry off thirty more by a little extra household economy (of course, she's never tried this before!) You can almost see the whole family lighting out for the savings bank with money you are yet to earn.

There's that early fall coal stunt, too. You remember how you always "saved" a nice wad on the winter's coal; the coming winter is always a mild one before it gets here. This is positive this time. Haven't the squirrels been ashamed to look a nut in the face? Aren't the birds lingering longer than they usually linger? And then, when winter does come, don't you usually buy more coal than last year?

Save? Oh, well, you may say you've lots of time to do that. Your job at the plant is good, anyway, for the next thirty years. In that case there is plenty of time—unless the boss intends to scrap the old "recips" and install turbines. Of course, he'll then say: "If you can run them, we'd like you to stay with us. If not—"

If not, you must look elsewhere. A few dollars in the savings bank will make this looking easier. If not—

It's great to be an optimist, it's good to *mean* to do things, it's fine to be a forehanded provider, but—

Are you?

Better give over *planning* the larger things and *do* a little one *now*! Persuade yourself that the crisp new five-spot you put in the bank today is a big sight more money on your book than the hundred you plan to put in out of next year's earnings.

Let this sink in deep. Do a little now, and get into the habit; then you'll keep on doing and getting.

South Power Station of the Blackstone Valley Gas and Electric Co.

By Warren O. Rogers

SYNOPSIS—A turbine plant in which there are four main units, with the condensing apparatus installed in the basement. Revolving screens are used at the intake of the condenser tunnel, which pick up any floating débris and discharge it into a trough from which it is washed to one side. A Gantry crane of the latest design, capable of discharging to the yard or boiler-house bunker conveyor, handles the coal from barges. The station is tied in with three other steam and hydro-electric plants, and is the main distributing station.

The South turbine power station of the Blackstone Valley Gas & Electric Co.'s plant, Pawtucket, R. I., is tied in with another but smaller steam station, a small hydro-electric plant and a combined steam and hydro-electric plant. The distribution of current is from the South station.

When the new station was built, in 1907, it consisted of one vertical turbine. A second unit of the same size was later installed. These main units are on hexagonal concrete foundations, which are nearly level with the floor of the turbine room. A metal grating around and between the unit makes it convenient for the operators. This arrangement affords ample basement room for all condensing apparatus, most of which is visible from the main floor on the switchboard side.

The Nos. 1 and 2 turbine units, Fig. 1, are each of 1500 kw. capacity and generate 2300-volt, three-phase, 60-cycle current at 900 r.p.m. with 175 lb. of steam. No. 1 turbine exhausts into a jet condenser. The condensing water runs into the low-head jet condenser under the influence of the vacuum and is removed by a double-acting, flywheel pump. A 12 and 24 by 18-in. steam-driven air pump is placed at the back of the foundation of the turbine it serves

The second vertical turbine is connected to a barometric condenser, Fig. 1, which is installed next to the wall separating the turbine and boiler rooms. Condensing water is supplied by a 9x10-in. vertical engine-driven 14-in. volute pump. A 10 and 20 by 18-in. dry-vacuum pump is used for removing the air and uncondensed vapor from the system. As the condenser is in the turbine room, a short connection is made to the turbine. The tail pipe of the condenser terminates in a concrete-lined brick hotwell in the basement. A vacuum of 28 in. and over is carried on these units.

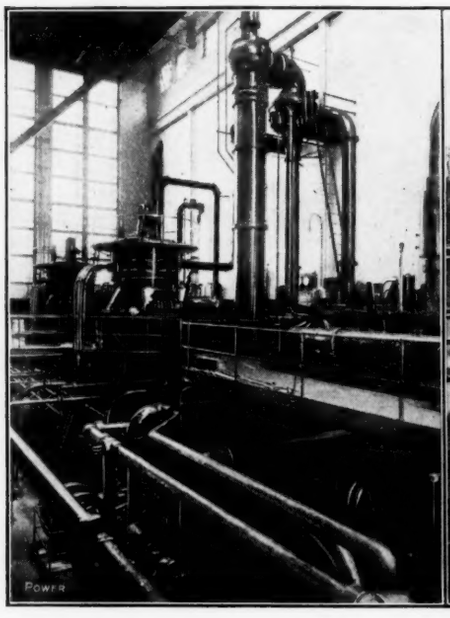


Fig. 1. Two Vertical 1500-Kw. Turbines and Jet Condenser

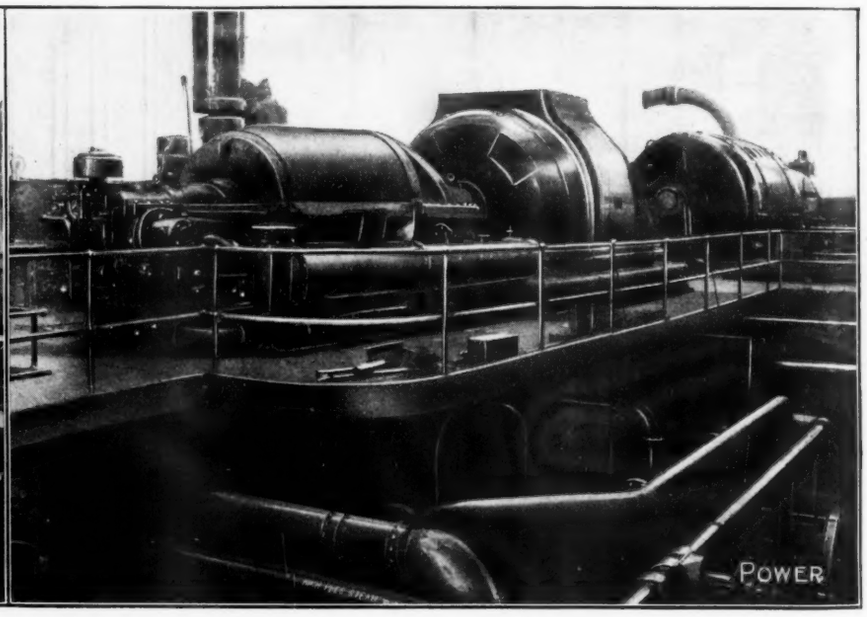


Fig. 2. Two Horizontal Turbine Units of 4500- and 12,850-Kv.-a. Capacity, Respectively

The third unit, installed about four years ago, of 4500-kw. capacity, is of the horizontal type and generates 2300-volt, three-phase, 60-cycle current at 1800 r.p.m. It is shown in the foreground of Fig. 2, on a level with the vertical units, and is surrounded by a concrete floor with a railing of pipe on the side next to the condenser basement.

This turbine is operated in connection with a "Type C" jet condenser which is so designed that a vacuum can be formed or recovered with a full load on the turbine without shutting off the steam going to the condenser and without the use of a stop valve in the main exhaust line.

All of the condensing apparatus is placed below the turbine; the exhaust opening is at the top and is connected to the expansion joint between the condenser and the turbine. With this arrangement, the steam travels about 3 ft. from the exhaust nozzle of the turbine before coming in contact with the condensing water.

In connection with the condenser there are two centrifugal pumps of different capacities mounted on the same shaft and driven by a single turbine. The larger pump, of the tri-rotor type, removes the water from the condenser, discharging it into the discharge tunnel. The smaller pump with a single impeller takes its suction from the common intake tunnel and discharges through two air-ejector nozzles into the discharge tunnel. This

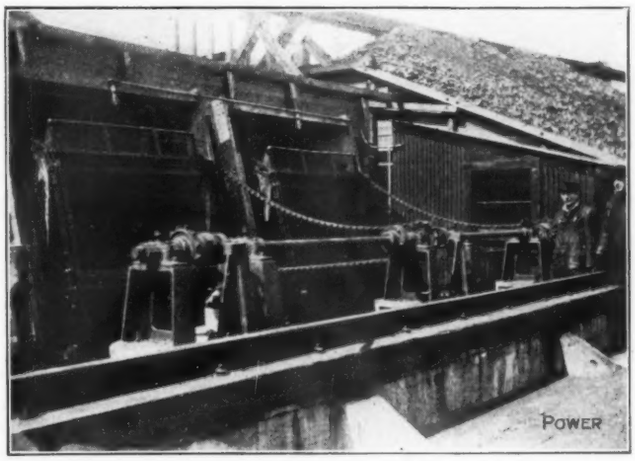


FIG. 3. REVOLVING SCREENS FOR CONDENSER INTAKE

action removes the air from the air and water-separating chamber of the condenser, discharging it with the water. The discharge from this pump can be shunted into the condenser, forming a forced injection for priming the condenser should the turbine for any reason be running noncondensing and it is desired to operate condensing.

The injection water enters the condenser at one end, at the bottom of the head, the amount of water being controlled by a main injection valve. The water flows through several troughs with notched sides which run lengthwise of the condenser at a point above the center line. The notches permit the water to overflow in a series of thin streams, and as the end of the trough furthest from the inlet is at a lower level than the other end, the most water is delivered where the steam enters the condenser. The thin streams flowing over the sides of the troughs mingle with the entering steam and cause the water to break into a fine spray.

The air in the water, upon liberation, passes to an air chamber from which it is removed through the suction line to the air ejector. Such parts of the trough under the exhaust-steam nozzle are protected by baffle-plates. The spray, formed by the combination of water and condensed steam, falls through the steam, which has passed around the ends of the trough to the lower section of the condenser, into the water which is retained in the bottom of the condenser shell. The depth is regulated by the height to which the discharge pipe is carried up into the condenser. Air entering the condenser with the exhaust steam passes up between the troughs and through the water flowing over their sides into the air-collecting chamber and mingles with the air which came in with the injection water.

This condenser, in addition to the air-jet nozzle, is connected to a 12 and 30 by 18-in. dry-air pump in front of the concrete turbine foundation.

The fourth unit which has just been installed is of 12,850 kv.-a. and generates 2300-volt, three-phase, 60-cycle current, at 1800 r.p.m. This unit, shown at the far end of Fig. 2, exhausts into a Leblanc condenser under the turbine and between the concrete-foundation columns. The turbine-driven injection and air pumps are mounted on the same shaft.

CONDENSING WATER

Condensing water was formerly taken from an intake tunnel which, owing to the tide variation, frequently caused trouble by an insufficient water supply. To overcome it, a new intake tunnel has been constructed 91 in. in diameter, and built so low that at low tide there is a depth of 8 ft. of water. The intake is protected against the entrance of leaves, grass and floating débris by stationary racks and by two revolving screens, Fig. 3. They

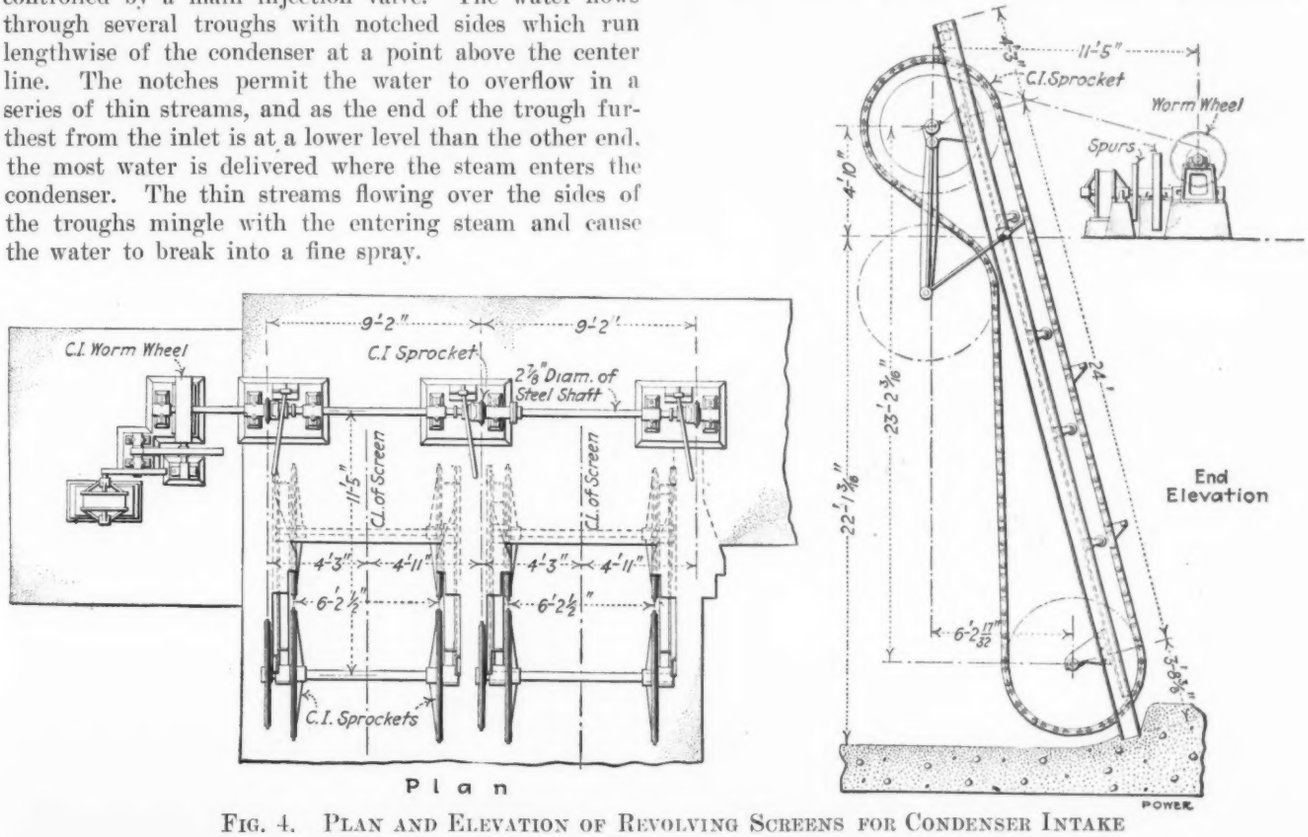


FIG. 4. PLAN AND ELEVATION OF REVOLVING SCREENS FOR CONDENSER INTAKE

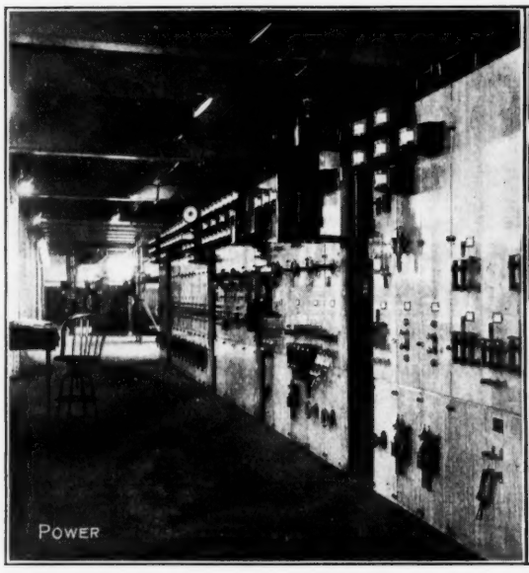


FIG. 5. MAIN SWITCHBOARD ON MAIN GALLERY

FIG. 6. ARRANGEMENT OF HIGH-TENSION BUSBARS ON THIRD GALLERY

are operated by chains and sprocket wheels from a shaft which is driven by a worm gear and a 10-hp. motor, installed in the shed, at the right of Fig. 3. The shaft driving the screens has a clutch so that one screen can be cut out of service for repairs, etc. Fig. 4 is a detail drawing of the phosphor-bronze screens. Each is 6 ft. wide and is fitted with bronze wire baskets spaced 7 ft. apart, each 10 ft. 10 in. wide at the top and 5 ft. 6 in. long. The screens are of ⅝-in. mesh wire. The screen sections are made of angle iron to which the wire mesh is secured, each attached to an endless chain at each end, composed of alternate long and short links, which run on large sprocket wheels. At the rear is a set of idler sprockets for adjusting the tension of the links. The

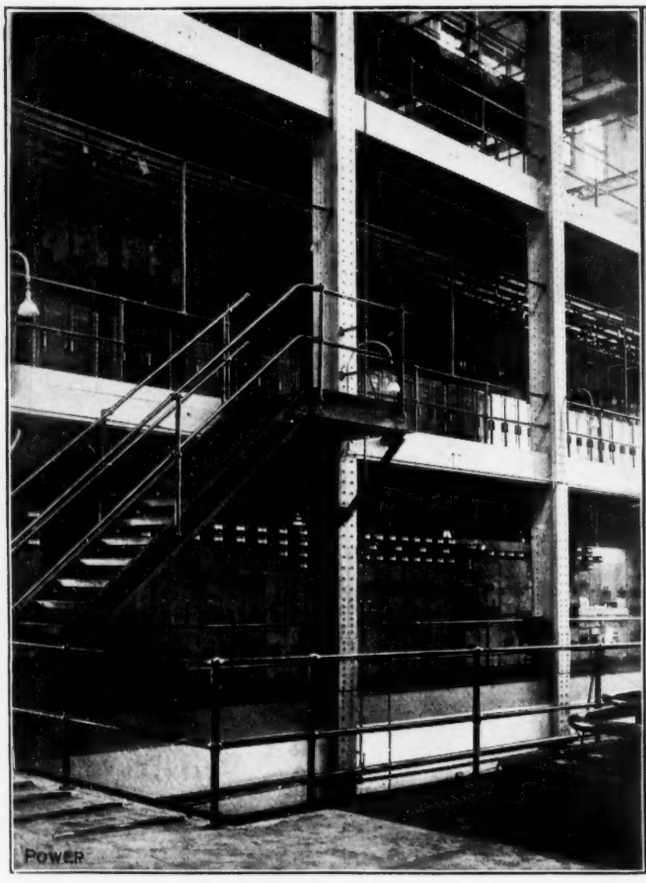


FIG. 7. GENERAL VIEW OF THE GALLERIES FROM THE TURBINE SIDE OF THE PLANT

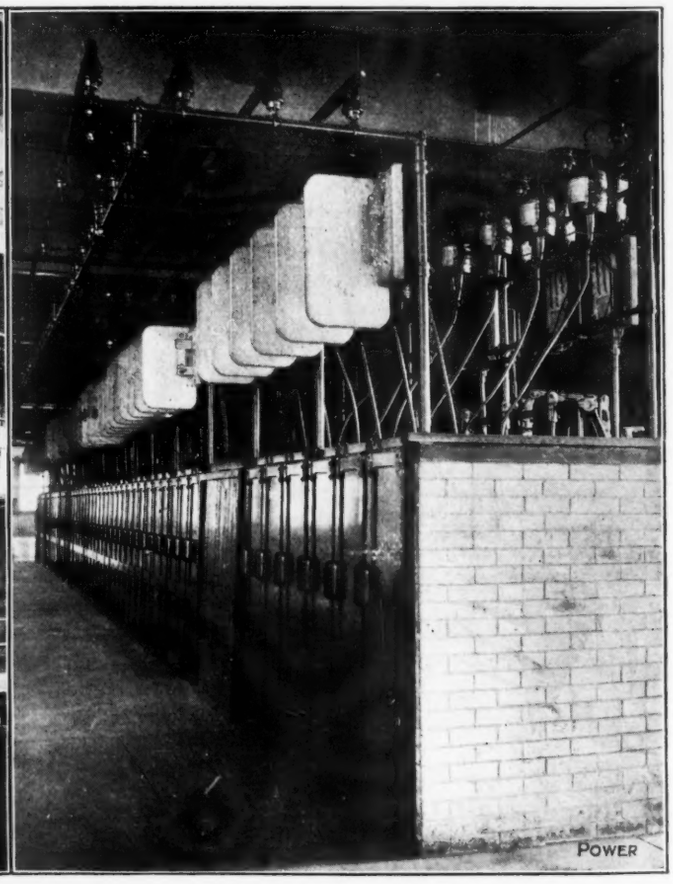


FIG. 8. VIEW OF THE OIL SWITCHES ON THE SECOND GALLERY

speed at which the screen travels is 1 ft. per min., with the motor running at 720 r.p.m. As the screen revolves any foreign matter that has passed through the racks is picked up by the buckets, carried over the top of the sprocket and discharged into a trough at the rear of the screens.

In case the leaves and grass stick, provision has been made to wash them from off the screens by jets of water discharged through perforations in a 1½-in. pipe on the inside of the rear of the screens. This water is supplied by a 3-in., 10-hp., motor-driven centrifugal pump. All rubbish, after being deposited in the receiving trough, is flushed out of the way as the accumulation requires. During the cold weather, jets of steam instead of water are discharged through the perforated pipes, which prevents the formation of ice. The screens are housed at the rear and top, as shown in Fig. 3, and are supported on the open side by the beams which carry the sprocket wheels.

FIG. 9. VIEW IN BOILER ROOM, LOOKING TOWARD THE TURBINE ROOM

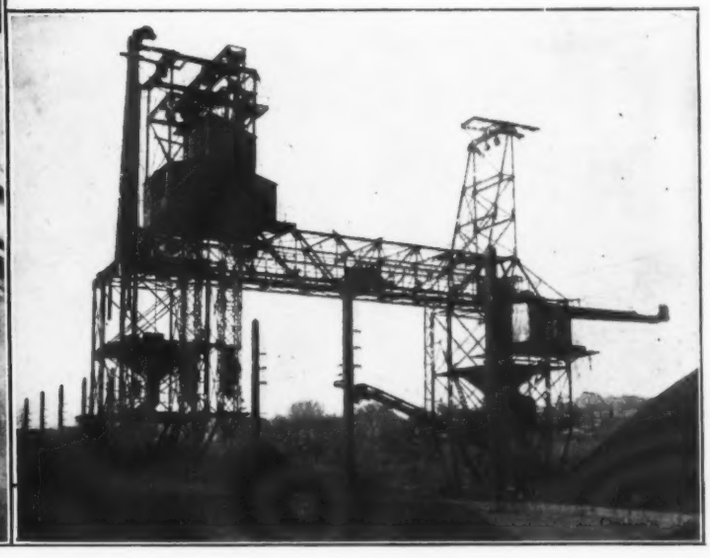


FIG. 10. GANTRY CRANE FOR UNLOADING COAL FROM BARGES TO THE YARD OR TO A BELT CONVEYOR

EXCITER UNITS

There are four exciter sets for the four generating units. One is of 35-kw. capacity, and is driven by a 35-kw. turbine at 3600 r.p.m., generating 125-volt current; another is a 40-hp., motor-driven, 125-volt, at 900 r.p.m.; the third, a 75-kw. turbine-driven set, at 3300 r.p.m.; the 75-kw. generator delivering current at 125 volts at 3300 r.p.m.; the fourth is a turbine-motor-driven set, the turbine being rated at 150 hp. On the opposite end of the generator shaft from the turbine is a 150-hp. induction motor. With this arrangement, the generator can be either turbine or motor driven.

PUMPS

The pump room is off the condenser basement under the boiler room, and contains two 6 and 2¼ by 10-in. duplex, outside-packed, step-bearing pumps which maintain a 400-lb. pressure on the step bearings of the two vertical turbine units. There is also an emergency motor-driven, triple-plunger, step-bearing pump. The three boiler-feed pumps are duplex, outside packed, with cylinders 12 and 7½ by 15-in. Artificial lighting is used because of the location of the pump room.

The switchboard, shown in Fig. 5, is on a level with the turbine floor but is separated from it by the condenser basement. At the far end are the mercury-arc rectifiers and arc-plug switchboards. On the gallery above the switchboard are the remote-control oil switches for the generators and feeder lines. On the gallery above these switches is another battery of remote-control oil switches and the high-tension busbars for the transformers and outgoing lines to the Woonsocket power house. A general view of the three galleries is shown in Fig. 7; the oil switches are shown in Fig. 8 and the arrangement of the high-tension busbars in Fig. 6.

BOILER ROOM

At the rear end of the turbine room is a passageway into the boiler room, which is at right angles to it. Here are installed ten 520-hp., water-tube boilers. Eight are equipped with one make of superheater and two have another. Each boiler furnace has a mechanical stoker, engine driven. Although there are four stoker engines, only two are used at a time, one for each battery of boilers, which are set in two rows with a firing aisle between. Fig. 9 is a view looking toward the turbine room. The boilers are served by two self-supported steel chimneys, one 12 and the other 16 ft. in diameter, and both 240 ft. high.

An electric truck used for removing the ashes runs directly under the ash hoppers for filling and then takes the ashes away for dumping.

Above the boilers is a coal bunker of 750 tons capacity. Over each stoker in the bottom of the bunker is a chain-operated coal valve discharging into four weighing hoppers with spouts, two for each side of the boiler room, traveling on light, overhead rails and propelled by a hand chain and sprocket.

Coal-Handling Apparatus

All coal is shipped to the plant in barges and unloaded by a gantry crane having two sources of discharge. Referring to Fig. 10, the crane, which runs on heavy rails, is equipped with two sets of crushing rolls. Coal is hoisted from the barge and can be discharged into the hopper above the right-hand rolls; after passing through them it goes to a short belt conveyor and is stored in the yard. If the fuel is for immediate use it is conveyed to the left-hand hopper and rolls and is discharged onto a belt conveyor, which runs beside the crane track next to the power house. The coal then goes to a bucket conveyor and is conveyed to the storage bin in the boiler house.

When coal is to be taken from the storage pile in the yard it is picked up by a clam-shell bucket and transferred to the long belt conveyor. As the crane has a long travel, a large coal-storage area is available. All operations and crane movements are by motor.

Miscellaneous

The pipe lines are not designated by the so called color system; the coverings are painted black, and the use to which the pipe line is put is painted on the covering in white letters, as shown in Fig. 2. For instance, all piping used for high-pressure steam is so marked, with an arrow pointing in the direction of the flow. Exhaust pipes are marked "Exhaust Steam"; water, oil and other pipes are marked according to the purpose for which they are used.

All transformers are in compartments under the main switchboard gallery on a level with the condenser basement. At one end of the engine room under the first gallery are two systems of air washing. One is a wet, the other a dry process. In the first, the air for cooling the turbine is passed through thin sheets of water before reaching the turbine; in the other, the air passes through cloth bags of special texture and design.

The chief engineer's office is at one end of the switchboard gallery, where there is also a waiting and small store room, washroom and toilet.

This plant was built by the Stone & Webster Engineering Corporation.

PRINCIPAL EQUIPMENT OF THE SOUTH POWER STATION OF THE BLACKSTONE VALLEY GAS & ELECTRIC CO.

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Turbines	Vertical	1500 kw.	Main units	175 lb. steam, 900 r.p.m., 2300 v., 3-phase, 60-cycle	General Electric Co.
1	Turbine	Horizontal	4500 kw.	Main unit	175 lb. steam, 1800 r.p.m., 2300 v., 3-phase, 60-cycle	Allis-Chalmers Co.
1	Turbine	Horizontal	12,850 kv.a.	Main unit	175 lb. steam, 1800 r.p.m., 2300 v., 3-phase, 60-cycle	Westinghouse Co's.
1	Condenser	Jet, reciprocating	18x34x18-in.	No. 1 turbine	Steam driven, 28-29-in. vac.	Deane Steam Pump Co.
1	Pump	Air, reciprocating	12x24x18-in.	Jet condenser	Steam driven, 175 lb. steam	Deane Steam Pump Co.
1	Engine	Vertical	9x10-in.	Driving volute pump	Steam driven, 175 lb. steam	Henry R. Worthington
1	Pump	Volute	14-in.	Condensing water	Engine driven, 175 lb. steam	Henry R. Worthington
1	Pump	Air	10x20x18-in.	On barometric condenser	175 lb. steam	Henry R. Worthington
1	Condenser	Barometric		Vertical turbine No. 2	28-29-in. vacuum	Henry R. Worthington
1	Condenser	Jet		With turbine No. 3	28-29-in. vacuum	Allis Chalmers Co.
1	Condenser	Leblanc	23	With turbine No. 4	28-29-in. vacuum	Westinghouse Machine Co.
1	Turbine	Terry		Condensate pump	175 lb. steam	Terry Turbine Co.
1	Pump	Triplex	12-in.	Condensate	Turbine driven	Allis-Chalmers Co.
1	Pump	Reciprocating	12x30x18-in.	Dry air, on jet condenser	175 lb. steam	Wheeler Condenser & Eng. Co.
2	Screens	Revolving	⅛-in. mesh	Condenser intake	Continuous, motor driven	Exeter Machine Co.
1	Motor	Direct current	10 hp.	Revolving screens	720 r.p.m.	General Electric Co.
1	Motor	Direct current	10 hp.	Centrifugal pump	1700 r.p.m.	General Electric Co.
1	Pump	Centrifugal	3-in.	Screen water	1700 r.p.m.	
1	Turbine	Curtis	35 kw.	Exciter set	3600 r.p.m., 175 lb. steam	General Electric Co.
1	Generator	Direct current	35 kw.	Exciter	3600 r.p.m., 125 volts	General Electric Co.
1	Motor	Induction	40 hp.	Exciter set	900 r.p.m., 2080 volts, 3-phase, 60-cycle	General Electric Co.
1	Generator	Direct current	35 kw.	Exciter	900 r.p.m., 125 volts	General Electric Co.
1	Turbine	Curtis	75 kw.	Exciter set	3300 r.p.m., 175 lb. steam	General Electric Co.
1	Generator	Direct current	75 kw.	Exciter	3300 r.p.m.	General Electric Co.
1	Turbine	Terry	150 hp.	Driving exciter	1175 r.p.m., 175 lb. steam	Terry Turbine Co.
1	Motor	Induction	150 hp.	Driving exciter	1175 r.p.m., 2300 volts, 3-phase, 60-cycle	General Electric Co.
1	Generator	Direct current		Exciter	1175 r.p.m.	General Electric Co.
1	Turbine	Curtis		Leblanc condenser	2500 r.p.m., 175 lb. steam	General Electric Co.
2	Pumps	Duplex	6x2¼x16-in.	Step bearing	800-lb. pressure	Henry R. Worthington
3	Pumps	Duplex	12x7½x15-in.	Boiler feed	175-lb. pressure	Henry R. Worthington
10	Boilers	Water tube	520 hp.	Main generators	175-lb. pressure, stoker fired	Babcock & Wilcox
8	Superheaters	Foster		On eight boilers	150 deg. superheat	Power Specialty Co.
2	Superheaters	Babcock & Wilcox		On two boilers	150 deg. superheat	Babcock & Wilcox
10	Stokers	Murphy		Boiler furnaces	Engine driven	Westinghouse MachineCo.
1	Crane	Gantry		Handling coal	Motor operated, intermittent	Robbins Conveyor Co.
1	Conveyor	Belt		Handling coal	Motor operated, intermittent	Robbins Conveyor Co.
1	Conveyor	Bucket		Handling coal	Motor operated, intermittent	Robbins Conveyor Co.

Production of Gasoline

By J. J. Blair

In the oil fields the crude oil either flows to the surface through the drilled wells or is pumped up. In either case, the wells have been driven to penetrate the strata which furnish the supply. This source is not an underground lake or pool, nor even a stream, but a very porous stone. In Pennsylvania it is sand, in Ohio it is limestone, in Kansas, sand, in Texas, limestone, and in the Western fields it is shale.

The oil in each instance is piped to a refinery where it is separated into several products. At each refinery there are a number of circular steel tanks holding from 50,000 to 75,000 bbl. of oil, and into these tanks the oil is pumped and held until needed. From these storage tanks the oil is pumped as required direct to the stills.

The stills are iron boilers usually about 12x30 ft. and are built in brickwork all in a row, resembling a battery of steam boilers. In the front end of each boiler there is a regular firebox, manhole, set of pet-cocks, and a thermometer. Those stills are fired by natural gas and are attended by unskilled labor.

The process of refining begins with the charging of the stills. The fire is turned up and distillation soon begins. From the vapor chamber on top of the boiler a pipe conveys the products of distillation to a condenser, consisting of a set of pipes from a freezing plant, run back and forth through a rectangular reservoir of water. From this condenser numerous pipes run to different parts of the refinery; some to storage tanks and others to departments where the product of the still is further

treated. Paraffin is made in one department, axle grease in another, soap, and a score of different kinds and grades of lubricating oils, lighter oils and gasoline, in other departments.

Depending on the principle of fractional distillation, the stills give off the different products as the temperature of the oil increases. The portion that first distills over contains a large percentage of pentane, commercially known as rhigolene. The next portion consists of hexane-gasoline which represents only about 14 per cent. of the crude oil treated. The next fraction consists of heptane, which is collected until the temperature rises to about 110 deg. C. and is commonly known as naphtha. The next succeeding fraction is collected below 150 deg. C. and is known as benzine (not to be confounded with benzene, of coal-tar origin).

Coal oil, or the kerosene of commerce, is the next portion; it distills over between 150 and 300 deg C. This product is refined by agitating it with 1 or 2 per cent. of sulphuric acid; later on in the process, lubricating oils are obtained. The tarry residue is treated for vaseline and paraffin and the resulting asphaltum is often burned beneath the stills.

Unless the production of the crude oil had increased in proportion to the demand for gasoline within the past few years, this source of gasoline was destined to fail. Chemists, however, got busy, and were able to increase materially the production of gasoline from crude oil. Still another method of meeting the increased demand was discovered in the production of gasoline from natural gas, and as a result a number of plants are now in operation for this purpose. Instead of distilling off the gasoline, it is obtained by compressing and freezing the gas into the resulting gasoline.

Will Quizz, Jr.

SYNOPSIS—Will found a little difficulty with the Engineer's Study Course in understanding how the sum of the components of a force can be greater than the force itself. Chief Teller explains that he has confused force and work.

My dear Chief: While you have been away I have been trying to follow the Course on Elementary Mechanics in POWER and got in trouble on the very first lesson in the issue of Mar. 24. It was stated that where a force of 200 lb. acts at an angle of 30 deg. to the horizontal, there is 173 lb. acting horizontally and 100 lb. vertically. Now, how can there be 100 lb. of wasted energy and 173 lb. of useful energy when the force applied is only 200 lb.?

The cosine of the angle is 0.866, which shows that 86 + per cent. of the force applied is going to useful purposes. Therefore,

$$1.000 - 0.866 = 0.134 = 13.4 \text{ } \textit{per cent.}$$

appears to me to be the energy wasted which would be

$$200 \times 0.134 = 27 \text{ } \textit{lb., about}$$

If we design a brace for a boiler it is worked out in this way. As, for instance, suppose we desire to stay a head and the brace is 1 sq.in. in cross-sectional area and is capable of standing a straight pull of 6000 lb. and be safe. If we place it at an angle of 20 deg. to the shell and still wish it to be capable of standing 6000 lb., we must use a stay enough larger to stand

$$6000 \times \textit{sec. } a = 6000 \times 1.0642 = 6385.2 \textit{ lb.}$$

and 385 lb. appears to me to be the wasted energy in this case. According to the mechanics lesson, it would be

$$6385 \times \textit{sin } a = 6385 \times 0.342 = 2184 \textit{ lb.}$$

I wish you would set me straight on this when you have time to write me.

All the boys send regards,

Yours respectfully,

WILL QUIZZ, JR.

Dear Will: Your letter received, and in answer I think I can quickly explain away your difficulty if you will just stop confusing in your mind energy and force.

Energy is the capacity of a body for doing work, and *work* is the *overcoming* of a *resistance* through a *definite distance*. Forces which hold a body in a state of rest do no work on the body and, therefore, no energy is generated or expended.

The problem in Lesson I means that if a force of 200 lb. were acting on a body at an angle of 30 deg. with the horizontal, there would be an *effective* force of 173 lb. tending to move the body in a horizontal direction, and a force of 100 lb. tending to move it in a vertical direction. Thus, assume a heavy casting resting on the floor of a shop. Fastened to the weight is a rope which makes an angle of 30 deg. with the horizontal. Now, if there is a pull on the rope of 200 lb., it simply means that the effective force tending to move the body along the floor is 173 lb., and the force tending to raise the casting from the floor is 100 lb.

Your statement relative to the design of the boiler stay is correct as far as the force of 6385 lb. is concerned. Here the horizontal force or component is 6000 lb. and the force or pull in the stay is

$$6000 \times \textit{sec } 20 \textit{ deg.} = 6385 \textit{ lb.}$$

It is also true that the vertical force or component due to the pull in the stay is

$$6385 \times \textit{sin } 20 \textit{ deg.} = 6385 \times 0.342 = 2184 \textit{ lb.}$$

which force tends to shear off the rivets holding the stay in place, and there is no "wasted energy" as the stay does not move.

Further, your statement that 86 per cent. of the force applied is going to "useful purposes" is correct, provided you mean "useful purpose" in a horizontal direction; but it is also true that 34 per cent. of the force is going to "useful purpose" in a vertical direction. The lesson on "Resultants of Force," in the succeeding issue, Mar. 31, should help to clear away your difficulty.

Don't get discouraged, Will. Mechanics is a little hard at first, but once you get into it you will enjoy it and find it one of the most profitable studies an engineer can take up.

Remember me to the rest of the fellows, and see if you can't get them interested in this mechanics' course, too, for it would do them all good.

Yours as ever,

TELLER.

How to Determine Type of Motor

By F. A. Annett

SYNOPSIS—Directions for determining by means of the leads whether a direct-current motor is shunt, series or compound wound. In very small motors the leads may be traced by the aid of a test circuit and lamp.

"What kind of a machine am I working with?" is a question that often confronts the electrician or engineer. In the medium- and large-size machines (2 hp. and up) this can usually be determined by inspection of the armature and field leads.

First, see if both the armature leads go to the external terminals, how many leads come from the field coils, whether they go to the external terminals; also, if there are small auxiliary poles (interpoles) between the main poles.

Assume a condition as in Fig. 1, where two leads come from the armature and two from the field coils which connect to four external terminals. If this machine is series wound, the armature and field leads will both be the same size, and of large cross-section. Sometimes, especially in small machines, one lead of the field is connected to one lead of the armature and only two terminals are brought out of the motor, as in Fig. 2. This does not alter the conditions, however.

If the machine is shunt wound, only the armature leads will be of large cross-section, while those of the field will be small, as indicated in Fig. 3. Also, the field terminals (lugs or connectors) will be small, while those of the armature terminals are large. On the series motor the field and armature terminals were large and of the same size. In some shunt motors a field and an armature lead are connected inside the machine and brought to the one terminal, as in Fig. 4. Again, in some very small machines the field coils are connected in multiple with the armature and only two terminals are brought out.

If the motor is compound wound, it will have two sets of fields. The series and the shunt coils are usually made up separately and placed on the polepieces, although in some cases the two coils are taped together before they are placed on the polepieces and look much like one coil, but they will always have four leads, two large and two small. These, together with the two armature leads, make six, which may be brought out to six terminals, as in Fig. 5; or one shunt and one series field may be connected to the same terminal, as in Fig. 6. Again, one of the series-field leads may be connected directly to the armature (brush), as in Fig. 7, making only four external terminals. As far as the number of terminals required to connect the motor to the ordinary starting box is concerned, the other series-field lead and one of the shunt-field leads may be connected together, making only three external terminals, as in Fig. 8. In general practice, however, compound motors have five or six terminals, as in Figs. 5 and 6.

The large terminals are those of the series field and the small ones those of the shunt field. This is very marked in the larger machines, the series field often being made of copper bar. The series field usually occupies from one-quarter to one-third the space on the polepieces occupied by the shunt-field coils, and may be placed either on the end of the polepieces near the armature or back against the frame.

If the machine is of the interpole type—that is, with auxiliary poles between the main poles—the interpole winding will always be in series with the armature. Like the series-field winding, it is of large cross-section as represented by the heavy lines in Figs. 9, 10 and 11. Referring to these illustrations, it will be seen that an interpole winding does not necessitate any additional terminals on the outside of the machine as one lead of the interpole is connected to one armature lead, leaving but one armature and one interpole lead to be brought to the outside terminals.

In the different classes of machines considered, the armature windings are the same, each machine deriving its name from the field winding and its connections.

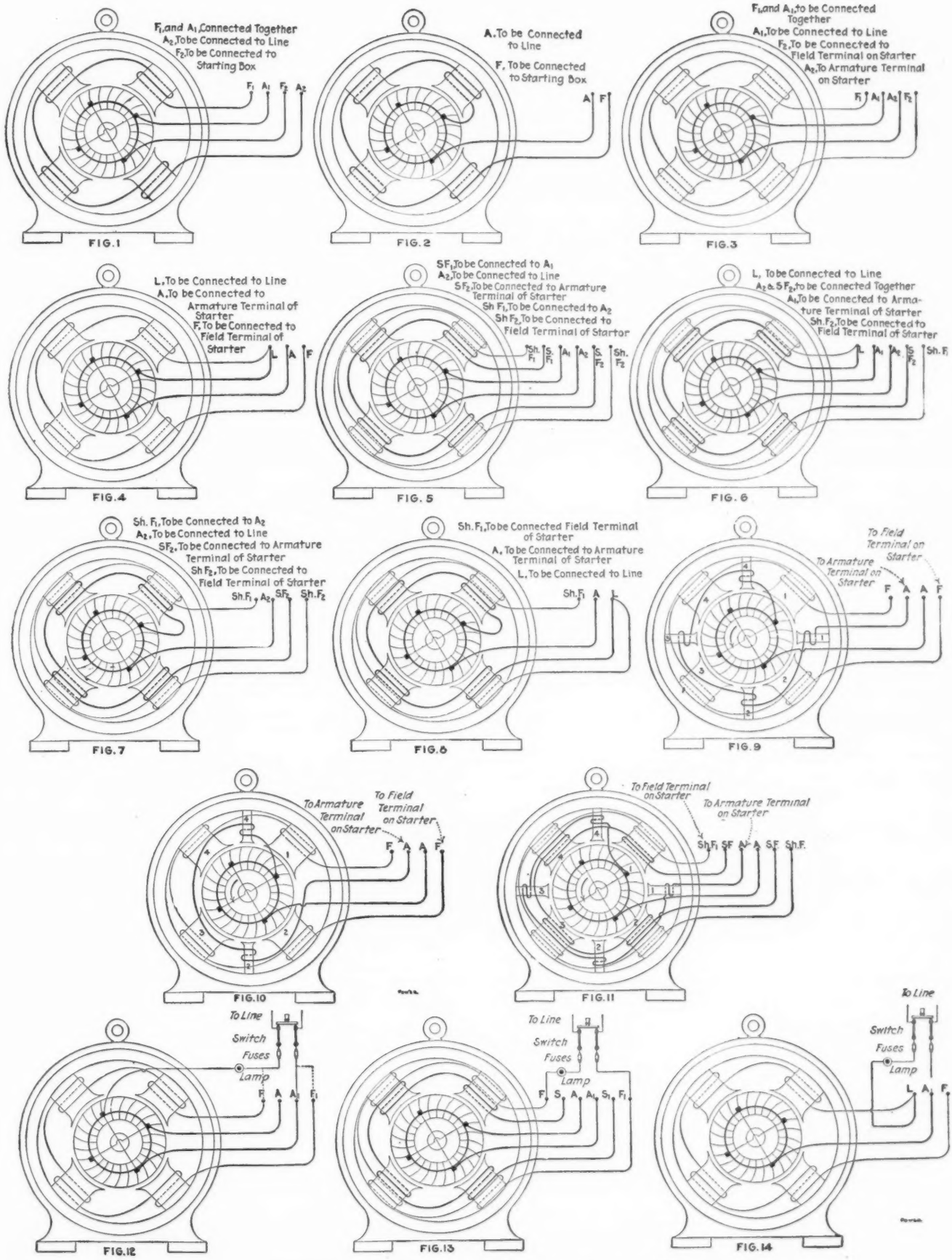
One thing that can be kept in mind is that a series motor is seldom used except in railway, electric-vehicle and crane service. In some cases, however, they are used to drive small pumps and blowers, but these are usually limited to sizes of 2 hp. and less. It is on the small-size motors that it is the most difficult to distinguish the different types; for instance, by referring to Figs. 1 and 3, both motors have four terminals brought to the outside and in sizes below 2 hp. the leads from both the armature and field coils are the same size, so it becomes necessary to make some kind of a test to determine whether the machine is shunt or series wound. This can be done by testing with a lamp.

First, place one terminal of the test circuit on the brushes, and with the other terminal connect to the various motor terminals until the lamp is lighted, as will be the case when connected as in Fig. 12. This will indicate an armature terminal. If one side of the test circuit is connected to terminals F or F_1 while the other side is connected to the brushes, the lamp will not light, as these are the field terminals, but when the test is made to terminal A, the lamp will again light. This will indicate the other armature terminal of the machine.

After the armature terminals have been located, connect the test circuit to terminals F and F_1, as shown by the dotted lines. If the lamp lights dimly the machine is shunt wound, and if brightly, the machine is series wound; also, if it is shunt wound a severe spark will occur at the field terminal when the test circuit is broken. This will not be the case if the motor is series wound.

There is another way that the machine can be tested to find if it is shunt or series wound, in case a test lamp is not available. First, connect the field and armature in series, as shown in Fig. 2, and the remaining terminals to the line. If the motor is series wound it will start up with a strong effort and will soon reach a very high speed if not loaded. On the other hand, if it is shunt wound, if it starts at all, it will be with a weak effort and at a very slow speed. In most cases, it will not start at all, but if the armature is turned by hand it will be found to have a tendency to turn in one direction, and when the line switch is open, there will be a severe arc.

In case the machine is compound wound and connected as in Fig. 7, there would be four terminals appearing on


F1 and A1 Connected Together
A2 To be Connected to Line
F2 To be Connected to Starting Box
F1 A1 F2 A2
FIG. 1
A. To be Connected to Line
F. To be Connected to Starting Box
A F
FIG. 2
F1 and A1 to be Connected Together
A1 To be Connected to Line
F2 To be Connected to Field Terminal on Starter
A2 To Armature Terminal on Starter
F1 A1 A2 F2
FIG. 3
L. To be Connected to Line
A. To be Connected to Armature Terminal of Starter
F. To be Connected to Field Terminal of Starter
L A F
FIG. 4
SF1 To be Connected to A1
A2 To be Connected to Line
SF2 To be Connected to Armature Terminal of Starter
Sh F1 To be Connected to A2
Sh F2 To be Connected to Field Terminal of Startor
Sh. F1 S. F1 A1 A2 S. F2 Sh. F2
FIG. 5
L. To be Connected to Line
A2 & SF2 to be Connected Together
A1 To be Connected to Armature Terminal of Starter
Sh. F2 To be Connected to Field Terminal of Starter
L A1 A2 SF2 Sh. F1
FIG. 6
Sh. F1 To be Connected to A2
A2 To be Connected to Line
SF2 To be Connected to Armature Terminal of Starter
Sh F2 To be Connected to Field Terminal of Starter
Sh. F1 A2 SF2 Sh. F2
FIG. 7
Sh. F1 To be Connected Field Terminal of Starter
A. To be Connected to Armature Terminal of Starter
L. To be Connected to Line
Sh. F1 A L
FIG. 8
To Field Terminal on Starter
To Armature Terminal on Starter
F A A F
FIG. 9
To Armature Terminal on Starter
To Field Terminal on Starter
F A A F
FIG. 10
To Field Terminal on Starter
To Armature Terminal on Starter
Sh. F1 SF A A SF Sh. F
FIG. 11
To Line
Switch
Fuses
Lamp
F A A1 F1
FIG. 12
To Line
Switch
Fuses
Lamp
F S A A1 S1 F1
FIG. 13
To Line
Switch
Fuses
Lamp
L A1 F
FIG. 14

EXTERNAL LEADS AS INDICATIVE OF TYPE OF MOTOR

the outside, as in Figs. 1 and 3, so along with making the test as described above it will be necessary to see that one of the armature terminals does not connect direct to the field coils. The terminals of a compound motor with its leads brought out, as in Fig. 5, may be located as follows:

First, test for the armature terminals as described in connection with Fig. 12; then connect one side of the test circuit to one of the four remaining terminals, such as F in Fig. 13, and then with the other test terminal make connections first on one and then on another of the three terminals, such as F_1, until the lamp lights. The test lamp is connected to the field winding shown in fine lines which indicates it is the shunt, and in that case the lamp will burn dimly, due to the high resistance of the field coils, and when the circuit is broken, a severe arc will occur as described for the shunt motor. This leaves two remaining terminals to be tested. When the lamp is connected to them it will burn brightly for the series field always has a low resistance. This is also true of the armature.

When one side of the armature and one shunt-field lead are connected to the same terminal, as in Fig. 4, and it cannot be seen just what terminals the leads run to, a test can be made as follows: First, disconnect one armature lead at the brushes or raise the brushes from the commutator. In Fig. 14, one armature lead is shown disconnected from the brushes. Connect one side of the test circuit to this armature lead. With the other side of the test circuit, test the outside terminals until the lamp lights. It will burn brightly if connected to terminal L, whereas, if the test circuit is connected to terminal F instead of L, it will burn dimly, for now the field is in circuit. When the lamp burns brightly, it indicates that the armature lead goes direct to terminal L and when dimly that the field is connected to L and F. If one side of the test circuit is connected to the brushes and the other to terminal A, it will again burn brightly, but if one test wire is allowed to remain on the brushes and the other is placed on F or L, the lamp will not burn; this will indicate that the armature lead alone connects to terminal A.

In a great many cases the manufacturers mark the terminals, and in most cases these marks can be relied upon as being correct when the machine comes from the factory, but if the machine is repaired it is not always in reliable and careful hands, and in some cases these markings are mixed up, consequently, the safest and surest method is to test the machine before it is connected up.

A Comparison of Boiler Standards

By J. W. F. Macdonald

While there has been considerable activity during the past few years in the United States as to the construction of steam boilers, it is interesting to note that a similar condition has existed in Canada, and already four provinces are enforcing rigid regulations governing such construction. In Alberta, Saskatchewan and Ontario the wording of the regulations is nearly identical. As to their application, some comparisons are here made with the rules of the state of Massachusetts and the different methods in treating details noted.

Approval and Registration of Designs

The rules of the Canadian provinces named state that before beginning the construction of any boiler, three blueprints of the complete shop-working drawings, with specifications in duplicate, must be submitted to the Department of Steam Boiler Inspection by the manufacturer for approval of the pressure and design, which must comply in all cases with the regulations. This applies as well to such fittings as stop valves, water gages and gage cocks, pressure gages and blowoff valves, etc. Approval will be given or corrections pointed out in the order the applications are received by the department, and the manufacturers are advised accordingly.

When finally approved, each particular design is given a registration number for each province and any number of boilers may be built according to the drawings of the design. In addition, each boiler shipped into the province must be accompanied by a copy of the approved specifications and an affidavit of the boiler-shop foreman, stating that the specifications have been carried out.

While the Massachusetts rules refer to some special cases which can be taken to the Board of Boiler Rules for approval, the inspection department does not make a practice of approving detail drawings, leaving it to the manufacturer to interpret the rules. While some delay may be caused awaiting the approval of new designs, according to the Canadian custom, it has, however, many advantages as it brings the inspector and the manufacturer in closer touch on questions of design and avoids any possibility of misinterpretation of the requirements, a condition which will invariably exist even with the most carefully worded regulations. Again, once a design has been approved, the manufacturer is assured that his boiler will be accepted if he follows his drawings and the workmanship is up to standard. Furthermore, as a fee of from $5 to $10 is required for approving and registering each design, it also has a tendency toward standardizing, using as few designs as possible.

Stamping and Identification

In Massachusetts each boiler must be stamped "MASS STD" with the name of the manufacturer, in full or abbreviated, and the firm's serial number. In Canada, in addition to the above details, the stamping must include the provincial letter and registration number of design, the lowest tensile strength of any shell plate in the boiler, with "S" for steel and "I" for iron; the name of the plate manufacturer and the date of construction, the latter giving the day of the month, numerical order of the month and last two figures of the year. The location of the stamp is practically the same in both cases. A sample stamping would be as follows:

In Massachusetts

MASS STD
976
I E W

In Alberta, Canada

International Engineering Works. Ltd. 78
A-563
57000-S
Lukens Iron and Steel Co.
16. 3. 14.

In addition, in Canada all new heating boilers must be stamped "For Heating Purposes Only" in some conspicuous place.

Factor of Safety

In Canada, the value used for the factor of safety varies over a wide range to suit different conditions and methods of construction. A base value of 4.5 may be used when the following conditions are complied with: The cylindrical shells of boilers must be made of the best material (either iron or steel), with all holes drilled in place from the solid plate, the plates afterward taken apart and the burrs removed. The longitudinal seams must be fitted with double-butt straps each at least five-eighths the thickness of the plate they cover, the seams being double riveted with at least two rows in double shear and having an allowance of not more than 75 per cent. over that of single shear.

The circumferential seams must be so constructed that the efficiency is at least one-half that of the longitudinal seams. The boiler must also be inspected during the whole period of construction by an authorized inspector.

When the foregoing conditions are not complied with, an addition must be made to the base value (4.5), according to the conditions in the following scale:

(a) Add 0.10 when the holes in the longitudinal seams are fair and good, but drilled from the solid out of place after bending edges of plate.

(b) Add 0.20 when the holes in the longitudinal seams are fair and good, but drilled from the solid out of place before bending edges of plate.

(c) Add 0.20 when the holes in longitudinal seams are fair and good, but punched after bending edges of plate and reamed after assembling.

(d) Add 0.30 when the holes in longitudinal seams are fair and good, but punched before bending edges of plate and reamed after assembling.

(e) Add 0.07 when the holes in the circumferential seams are fair and good, but drilled from the solid out of place after rolling plates.

(f) Add 0.10 when the holes in the circumferential seams are fair and good, but drilled from the solid out of place before rolling plate.

(g) Add 0.10 when the holes in the circumferential seams are fair and good, but punched after rolling plate and reamed after assembling.

(h) Add 0.15 when the holes in the circumferential seams are fair and good, but punched before rolling plate and reamed after assembling.

(i) Add 0.70 when the longitudinal seams are not fitted with butt straps, but are lapped and double riveted.

(j) Add 0.50 when the longitudinal seams are not fitted with butt straps, but are lapped and triple riveted.

(k) Add 0.60 when the longitudinal seams have only single butt straps and are double riveted.

(l) Add 1.00 when in the longitudinal seams any description of joint is used which is only single riveted or where double butt straps are used and only row of rivets is in double shear.

(m) *Add 0.50 when the holes or rivets in longitudinal seams are not fair and good.

(n) *Add 0.20 when the holes or rivets in circumferential seams are not fair and good.

(o) Add 0.40 when the holes in any seams are not properly spaced in crossing.

(p) *Add 0.40 when the material is doubtful and not properly stamped in accordance with the regulations.

(q) Add 0.50 when the joints are not close fitting and the plates are open when the boiler is finished and the workmanship unsatisfactory.

(r) Add 0.50 if the boiler has not been inspected by an authorized inspector during the whole period of construction in accordance with the regulations.

(s) When any boiler has been subjected to overheating, strains by forcing, crystallized by age or otherwise impaired, the factor of safety shall be increased according to the discretion of the inspector.

When marked "*," the inspector may, according to circumstances, increase the factor given and in the event of satisfactory information not being obtainable, the inspector shall use a basic factor of safety of five with such additions as his judgment may dictate.

In the foregoing (a), (b), (c), (d), (e), (f), (g), (h) must be used separately but may be added, when justified, to either (i), (j), (k,) (l), (m) or (n) separately and to (o), (p), (q), (r) separately or to the four latter when calculating the efficiency of a joint.

To those who are accustomed to the Massachusetts or similar rules, such a variable value for the factor of safety will appear complicated, and instead of providing for such a number of conditions under which a boiler may be constructed, it will appeal to many engineers and inspectors that it is better to demand a standard form of construction in the details referred to and use a fixed factor of safety for new construction. The Massachusetts rules fix this value as *five,* but give specific requirements as to the drilling or reaming of rivet holes, limitations of lap seams, properties of material, etc. Poor workmanship is, of course, a feature which the most rigid rules cannot wholly overcome, and, although section (q) in the Canadian rules is provided for that purpose, it becomes a question of the judgment of each inspector, and as different men will have different ideas, the rulings made will be likely to vary more or less.

Riveted Joints

The Canadian rules cover the design of riveted joints in much greater detail than the rules of Massachusetts, which refer to methods only for calculating the efficiency, leaving the design to the manufacturer.

The pitch of the rivets is limited by the formula

$$P_m = (C \times T) + 1\tfrac{5}{8}\ in.$$

where

P_m = Maximum pitch in inches of the rivets immediately inside the calking edge;

T = Thickness of the plate in inches;

C = Constant, applicable from Table 1.

TABLE 1

No. of Rivets in One Pitch Inside the Calking Edge	Constant for Lap Joint	Constant for Double Butt Joint
1	1.31	1.75
2	2.62	3.50
3	3.47	4.63
4	4.14	5.52
5	....	6.00

For example, in a triple-butt joint, using ½-in. plate, the maximum pitch of rivets inside the calking edge would be

$P_m = (3.50 \times \frac{1}{2}\ in.) + 1.625\ in. = 3.375$ *or* $3\frac{3}{8}\ in.$

In addition to limiting the pitch, formulas are also given for determining the minimum distance between the rows of rivets—that is, the transverse spacing. Such limitations all tend toward similarity of design among different manufacturers and discourage the use of freak designs. Chain-riveted joints are prohibited by the Canadian regulations, which allow for staggered types only. The number of rows of effective rivets is limited to three, whether in lap- or butt-strap construction; consequently the ordinary form of quadruple butt joint now in such general use in American practice is not allowed.

For calculating the efficiency of joints, the method of procedure is somewhat different, although the formulas are all similarly derived. In Massachusetts, the joint has to be calculated to find the actual pull required to rupture a repeating section by all possible methods of failure.

In making these calculations a fixed value of 42,000 lb. per sq.in. is given for single shearing of steel rivets and 78,000 lb. per sq.in. for double shearing. For the tensile strength of the plate, that stamped on the plate is to be taken, a value which may vary from 52,000 to 62,000 lb. and still be within the limits of the required physical properties. There does not appear to be any reason why the shearing strength of the rivets should not vary within certain limits just as well as the tensile strength of the plate; consequently it does not seem consistent that one value should be fixed and the other be variable. In the Canadian rules, instead of using actual values for tensile and shearing strength, a ratio is given between the two, the value of which depends on the material used. For example, when using steel plates and rivets

$$\frac{\textit{single shearing strength of rivets}}{\textit{tensile strength of plate}} = \textit{a constant} = 0.7$$

for steel plates and rivets. This appears to be a more consistent method, and has, in addition, a further advantage of simplifying the formulas in their application. The double shearing of rivets is taken as 1.75 times the value of single shearing; consequently rivets in double shear are always expressed in terms of rivets in single shear. The crushing strength of material in plate and rivets given as 95,000 lb. per sq.in. of projected area in the Massachusetts rules is not referred to in the Canadian regulations.

Stayed Surfaces

In the Canadian rules, the maximum stress allowable on flat surfaces shall be determined by the following formula: All stayed surfaces formed to be a curve the radius of which is over 21 in. are to be considered as flat surfaces:

$$\textit{working pressure} = \frac{C \times t^2}{p^2}$$

where

t = Thickness of plate in sixteenths of an inch. Where doubling plates are used, for t take 75 per cent. of the combined thickness of both plates;

p = Pitch of stays in inches when equally spaced in both directions;

C = Constant varying from 112 to 200, depending on conditions which take into account the style of staying used—that is, screw stays riveted over; screw stays with nuts; through stays with nuts inside and outside of plates; through stays using nuts or doubling plates, the latter having a thickness at least equal to that of the plate; through stays for plates stiffened with angle or tee bars.

For screw stays, the Massachusetts rules use the following formula:

$$\textit{working pressure} = \frac{C\,(t + l)^2}{S^2 - 6}$$

where

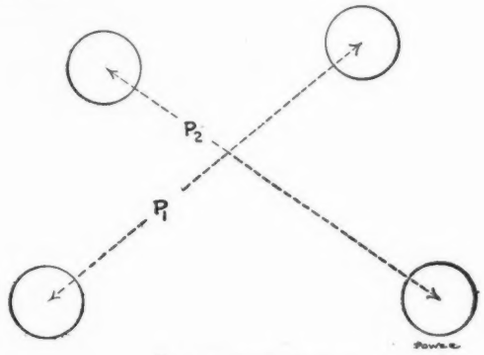
C = A constant = 66;

t = Thickness of plates in sixteenths of an inch;

S = Pitch of stays in inches.

For screw stays the Canadian formula will not give as great a pressure on thin plates, but will allow a greater pressure on thick plates. For example, $\frac{5}{16}$-in. plate, with stay-bolts pitched 5 in. on centers, is allowed a working pressure of 112 lb. in Canada and 125 lb. in Massachusetts, while $\frac{1}{2}$-in. plate with stay-bolts 7 in. on centers is allowed a working pressure of 156 lb. in Canada and 124 lb. in Massachusetts. No special provision is made in the Massachusetts rules for stays with nuts and washers or for the use of doubling plates. The latter is a convenient method of stiffening irregular flat surfaces and in many cases can be used to great advantage, particularly on the Scotch type of boilers.

The Canadian rules also make special provision for unequal pitches, thus where l = the pitch of stays in inches in one row and w = the distance in inches between two rows, then $\frac{l^2 + w^2}{2}$ is to be taken instead of p^2. Also, in cases of irregular staying, such as shown in the illustration



Irregular Stays

$\frac{(P_1 + P_2)^2}{8}$ is to be taken instead of p^2.

For the maximum working stress on stays, the Canadian rules allow 5000 lb. per sq.in. for welded-iron stays and 7000 lb. per sq.in. for iron stays without welds. For steel stays less than $1\frac{1}{2}$ sq.in. of net sectional area, 8000 lb. per sq.in. is allowed, and for $1\frac{1}{2}$ sq.in. or over of net area, 9000 lb. per sq.in. Steel stays must not be welded in any way.

The Massachusetts rules allow working stresses as given in Table 2.

TABLE 2

Type of Stay	Material	Maximum Allowable Stress per Sq.In. Up to and Incl. 1.227 Sq.In. of Net Area, Lb.	Maximum Allowable Stress per Sq.In. Over 1.227 Sq.In. of Net Area, Lb.
Head to head or through	Weldless mild steel	8000	9000
Head to head or through	Weldless wrought iron	7000	7500
Diag. or crowfoot	Weldless mild steel	7500	8000
Diag. or crowfoot	Weldless wrought iron	6500	7000
Head to head through diag. or crowfoot	Welded steel	6000	6000
Screw staybolts	Mild steel or wrought iron	6500	7000

For any diagonal stay, the Massachusetts rules do not directly take into account the angle which it makes with the supported surface, but instead reduces the allowable working stress from that allowable on direct stays, as noted in the table. For such stays, the Canadian rules allow only a stress equivalent to the allowable direct stress multiplied by the cosine of the angle made with the shell, this angle not to exceed 30 deg. Butt welding of the crowfeet or palms ends to the stays is prohibited. Another important point not covered in the Massachusetts rules is that the rivet area for attaching stays

of all kinds to a head shall aggregate 20 per cent. greater than the stay area; also, when through stays are attached to angle or tee bars by a bolt or pin in double shear, such bolt or pin need only have an area of 75 per cent. that of the stay.

In staying the segments of the head above the tubes in horizontal return-tubular boilers or any similar design, the Massachusetts rules assume that the outside of the head is self-supporting for a distance of 3 in. in from the edge, it is also supported by the tubes for a distance of 2 in. from its edge. This is irrespective of the thickness of the plate, the radius of curvature of the flange, or the working pressure.

In the Canadian rules the distance in from the edge of the flange, which is considered self-supporting, is taken as

$$\tfrac{1}{2}\sqrt{\frac{112 \times t^2}{B}}$$

or the radius of curvature of the head flange, whichever is the greatest. For the support given by the tubes the distance from the edge, considered self-supporting, is taken as

$$\tfrac{1}{2}\sqrt{\frac{112 \times t^2}{B}} - \frac{dr}{2}$$

In these formulas

t = Thickness of the head in sixteenths of an inch;
B = Working pressure;
dr = Diameter of the tube hole.

Cylindrical Shells

For calculating the pressure allowable on cylindrical shells the formulas, while in slightly different form, both give the same result.

For dished heads, concave to pressure, the Canadian rules state that when they are true portions of spheres and dished to a radius equal to or less than the diameter of the shell, they do not require staying if the thickness is $\frac{1}{16}$ in. more than the shell, but when dished to a radius greater than the diameter, the working pressure allowable may be calculated by the formula

$$B = \frac{(t - l) \times T.S.}{R \times 56}$$

where

B = Working pressure;
t = Thickness of plate in sixteenths of an inch;
$T.S.$ = Tensile strength of plate;
R = Radius to which the head is bumped.

In the Massachusetts rules the working pressure on a head concave to pressure is given by the formula

$$P = \frac{t \times T.S.}{F.S. \times R}$$

where

P = Working pressure;
$T.S.$ = Tensile strength;
$F.S.$ = Factor of safety = 5;
R = One-half the radius to which the head is dished;
t = Thickness of plate in inches.

The Massachusetts rules allow a greater pressure for the same head. For example, a head 48 in. diameter, $\frac{7}{16}$ in. thick, dished to a radius of 48 in. and having a tensile strength of 60,000 lb. per sq.in., would be allowed 218 lb. working pressure in Massachusetts. By the Canadian rules such a head would not be used with a shell over $\frac{3}{8}$ in. in thickness. A shell of this thickness which, when fitted with the most efficient joint allowed, and with the lowest factor of safety, would not give over 180 lb. working pressure.

For heads convex to pressure, both rules allow only 60 per cent. of the pressure allowed on heads concave to pressure.

For externally fired boilers, the Canadian rules limit the diameter to 72 in., and all horizontal return-tubular boilers 48 in. in diameter and over must have a manhole in the front head below the tubes. Massachusetts does not limit the size of such boilers and a manhole in the front head below the tubes is not required in boilers under 60 in. in diameter. The Canadian rules also take up the construction of manholes, handholes and yokes with reference to material and design in much greater detail. They also give formulas for calculating the working pressure on the Adamson and corrugated types of furnaces, Truncated cones and many other special details not covered in the Massachusetts rules.

The specifications for material are practically the same in both cases, although shells may be made of flange steel in Canada while Massachusetts requires the firebox.

There are many other minor details which could be mentioned, but those given cover the most important. Doubtless, opinions will vary widely as to the merits of the respective rules, but in any case both have proved that they tend toward the production of high-class boilers.

⁂

Highest and Largest Chimney—A chimney 506 ft. high, the tallest in the world, has been built for the Boston and Montana smelters at Great Falls, Mont. Its nearest rival is 40 ft. shorter and the next highest in America is 140 ft. shorter. The main barrel of the chimney has an inside diameter of 50 ft. at the top and about 65 ft. at the base; its discharge capacity is 4,000,000 cu.ft. of gas per minute. There are 17,000 tons of brickwork in the entire structure, and the foundation, which is 103 ft. across at the bottom and 22 ft. 6 in. high, contains 4300 cu.yd. of concrete. An octagonal base, 78 ft. 6 in. across the bottom and 46 ft. high, separates the main barrel from the foundation. A dust chamber, 478 ft. long, 176 ft. wide, and 21 ft. high, closely hung with small wires, strains the smoke before it enters the chimney. The flue which leads from the dust chamber to the chimney is 40 ft. wide and 1238 ft. long. The whole chimney has an acid-proof lining.—"Popular Mechanics."

⁂

Travels of a Flywheel—A recent issue of "Popular Mechanics" mentioned an engine that has been running in New York City for about fourteen years, and that a mark on its flywheel during that time would have traveled a distance equal to nearly 200 times around the earth.

The Corliss engine built by the Crane Co., in 1880, and which ran one of the company's Chicago plants continuously for 30 years, had a record of travel that compares favorably with that of the New York engine, taking into consideration size of flywheel, revolutions per minute, running hours and actual working days. The New York engine has a smaller flywheel, but it runs 22 hours a day, 365 days a year, and makes three times as many revolutions a minute. The Crane Co.'s stanch old Corliss ran for 30 years, 10 hours of every working day, and during that time had a fly sat on one spot of the flywheel rim it would have traveled 2,500,000 miles, or about 100 times around the world.

⁂

The Foundation of Education—"Technical school is not the education of an engineer—it is merely the foundation upon which the complete structure of education is built by work, experience and further study." So Charles T. Main, '76, expressed his ideas of the engineer and his training before the banquet of the Mechanical Engineering Society at Boston recently.—"The Tech."

Baffling Water-Tube Boilers*

By Osborn Monnett†

SYNOPSIS—Different types of baffle for different boilers and the best length of gas pass to use in each case.

The ratio of heating to grate surface may be higher than in return-tubular boilers, especially where mechanical stokers are used. Ratios from 40 to 60 to 1 are allowable. At the higher ratios, however, it must be remembered that the furnace will be loaded to its maximum capacity before the capacity of the boiler to absorb heat is reached, so that the chances of making smoke on high capacities are increased. All things considered, a general average of 50 to 1 is a good ratio in the ordinary water-tube boiler plant using Middle Western bituminous coals. This ratio provides for a good overload capacity on the boiler without actually taxing the furnace to attain it.

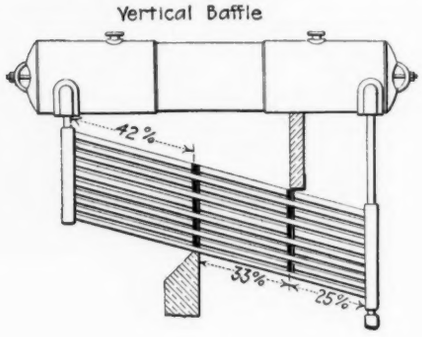


FIG. 1

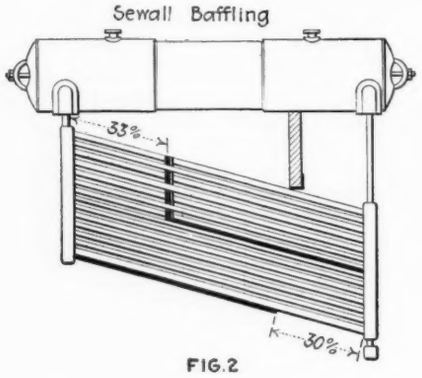


FIG. 2

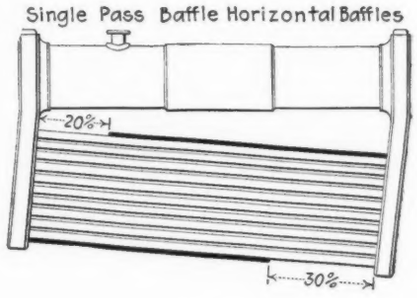


FIG. 3

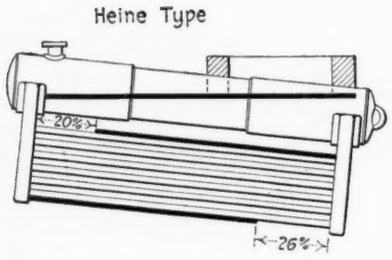


FIG. 4

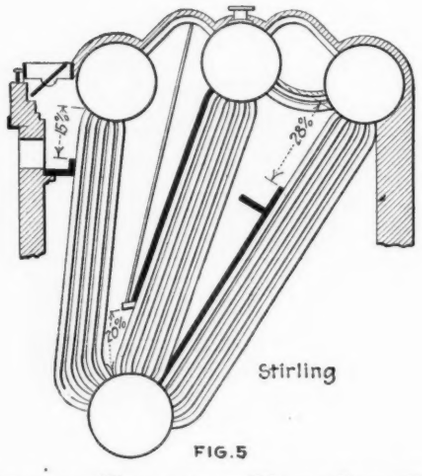


FIG. 5

Approximate Mean Length of 1st Bank of Stirling Tubes

CLASS	LENGTH
A	14'-2"
B	11'-6"
B (Low)	10'-4"
E	12'-8"
F	15'-9"
G	16'-9"
I	15'-3"
I-S	14'-9"
K	17'-5"
L	17'-6"
M	20'-2"
N	20'-0"
O	19'-10"
P	13'-6"
Q	16'-0"
R	17'-0"
S	15'-7"

Power.

Fig. 1. Spacing of Vertical Baffles on Horizontal Water-Tube Boilers. Fig. 2. B. & W. Sewall Baffling. Fig. 3. Single-Pass Horizontal Baffles. Fig. 4. Heine Type Baffling. Fig. 5. Stirling Baffles

Baffling

A careful study of the areas through water-tube boilers using different types of baffle has revealed some interesting points. In the following discussion it should be remembered that types rather than actual makes are considered. There are two ways in which the openings in the baffling may be expressed; one in percentage of tube length and the other in percentage of connected grate surface. As the grate surface will vary according to the ideas of different designers, it is better to classify the gas passes in percentage of tube length. This is standard in different makes of boiler and is a fixed dimension which cannot well be changed by the engineer in laying out the plant.

Vertical Baffling—With any water-tube boiler that can be baffled, as in Fig. 1, the following percentages expressing the relation between length of gas pass and tubes have given good results: First pass, 42 per cent.; second, 33 per cent.; third, 25 per cent.

B. & W. Sewall Baffling—The average proportions, worked out from many successful installations, are given in Fig. 2. With a superheater, the second gas pass should be increased to 37 per cent. of the tube length. It is not advisable, however, to use this baffle on boilers less than 12 tubes high.

Single-Pass Horizontal Baffling—Fig. 3 shows a good arrangement for water-tube boilers, such as the Atlas, Aultman-Taylor, Babcock & Wilcox, Bass horizontal, Erie City, Cahall horizontal, Edge Moor, Flanners, Free-

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†Smoke inspector, city of Chicago.

man, Oil City (Geary), Kingsford, Keeler, Wickes horizontal, etc. As indicated, the first pass is 30 per cent. and the second 20 per cent. of the tube length.

Heine Baffles—Under this heading are included all boilers having tube spacing similar to the Heine and other boilers not suitable for vertical baffles, such as the Casey-Hedges, Kroeschell, Franklin, Goss, Parker, etc. The gas passes for this type of baffle have given best results when proportioned, as shown in Fig. 4.

Stirling Boiler—From the standpoint of smoke suppression, the openings in the Stirling baffles, as ordinarily installed, are small and cause loss of draft through the setting. This tends to prevent smokeless operation at high capacities. The ordinary furnace, either stoker- or hand-fired, designed for smokeless operation, requires more brickwork than the standard types and naturally there is a tendency toward restriction of the gas passes. Carrying this too far has a detrimental effect on the brickwork and results in an unsatisfactory installation. The baffle openings recommended for this type of boiler, as shown in Fig. 5, are: First pass, 28 per cent. of the mean length of the first bank of tubes; second pass, 20 per cent., and third pass, 15 per cent.

Many experiments have been made with the baffling in water-tube boilers to increase efficiency, and it has been found that, up to a certain point, restricting the gas passes has resulted in higher efficiency. This is probably due to the higher velocity of the gases and to the consequent increased heat absorption. Restriction of the gas passes, however, can be carried to excess in natural-draft installations, as the draft available is generally too low to overcome much additional resistance. The gas-pass dimensions given herewith represent commercial proportions that have been found satisfactory from the standpoint of smokeless operation, steaming capacity and efficiency.

Stopping Leaks in the Absorption Plant

By William S. Luckenbach

SYNOPSIS—What to use to test water for ice making to determine the presence of objectionable impurities. Where to look for leaks and how to stop them. How to clean the perforated weak-liquor pipe in the absorber without shutting down the system.

Simple Tests for Purity of Water

The water from which ice is made should be occasionally tested for its purity. If lime is present, carbonate of soda produces a white cloud; should the water contain iron, yellow prussiate of potash will turn water blue; if copper is present, the same chemical will turn water brown. Acetate of lead added to water containing sulphur impurities will cause it to turn black. For testing the presence of ammonia in water, there is nothing better than a few drops of Nessler solution* in a glass of the water or brine.

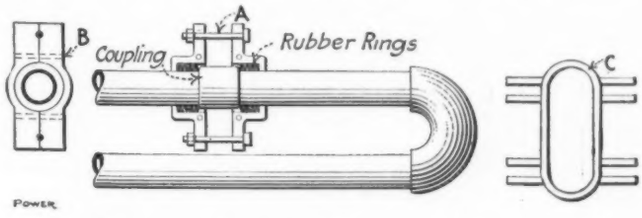
Leaks in the Exchanger

Suppose the hydrometer test shows the density of the rich liquor in an absorption machine to be 26 deg. Baumé, and the poor liquor 18 deg., equaling a distillation of 14 per cent. Now assume that the next test would show the weak liquor, say, 20 deg., or a distillation of only about 12 per cent., what is the cause and what is the remedy? There is only one cause, viz., not enough heat to liberate the gas, due to the generator coils or tubes not being clean or the steam of a lower temperature. This must be rectified at once in order to maintain capacity by either cleaning the coils or by increasing the steam temperature, or by using a larger volume at the same temperature.

Again, suppose the rich liquor decreased to 24 deg. and the poor liquor increased to 20.5; it is plain that there has been an exchange of ammonia, and as this can only occur in the exchanger, it must be cut out immediately by running a bypass temporarily and replacing the old coils or tubes with new as soon as possible. If this very important part of the system is thoroughly examined under a pressure of 500 lb. during the slack season, this trouble will be avoided, as well as the loss of several tons of ice when it is badly needed.

Leaks in the Absorber

When making the usual daily test of the water for ammonia leaks, should ammonia be found in the water flowing from the absorber, apply the same method to locate the coil or tube as described for the generator in a former



Stopping Ammonia Leak at Coupling

article.† Should the perforations in the weak-liquor pipe extending into the absorber become partially closed, thus decreasing the supply necessary to absorb the return gas, the first move is to close the weak-liquor valve and get a vacuum on the absorber by keeping the ammonia pump running; then, by suddenly opening wide the poor-liquor valve, the excessive pressure may force the substance out and open the holes. Should this fail, be prepared to act quickly by again getting a vacuum, then disconnect the perforated pipe, pull it out, close the opening and clean and replace the pipe as soon as possible.

An automatic-regulating valve, to control the flow of the poor liquor, should be installed in every absorption plant. It is guaranteed to control the poor liquor just the same as a governor controls the varying steam pressure or load on an engine. Hence, when once properly

*See "Power," Mar. 31, p. 450.

†"Power," May 5, p. 634.

adjusted, it will give the engineer ample time to carefully go over the plant and note the improvements he can make that will quickly return the investment for the improvement. The reason for advocating this adjunct is that the ordinary poor-liquor valve needs fairly close attention, as any change in the pressure of either the generator or the absorber will, of course, affect the flow of the liquor.

Leaks in Atmospheric Condensing or Cooling Coils

If, in testing the cooling water, ammonia should be present, it is important to stop the leak at once. It can usually be traced by white spots on the pipe or at threaded couplings and return bends, for in a few days the leakage will show a white incrustation. An ordinary band clamp bent to conform to the pipe and sheet of rubber will remedy the trouble, but in case the leak is in the threads of a coupling or return bend a split collar recessed for two quarter-inch rubber rings and then bolted together, as shown in cross-section at *A*, will effectually stop the leak without putting any strain on the threads or pipe.

The same split collar can be used on the return bends by making a pattern to suit the return bend, as shown at *C*. This collar is made of cast iron, with no machine work except drilling the two bolt holes shown in dotted lines at *B*.

The pattern has a thin core print nearly cutting the collar in two, and in order to split it after the bolt holes are drilled, simply drive a wedge or chisel in the cored slot. These collars are useful for other emergency repairs, and it is well to have at least two each of the various sizes on hand as ammonia leaks are far more expensive than a few cast-iron collars.

Coal Efficiency

By Haylett O'Neill

SYNOPSIS—Showing the influence of the ash, moisture and hydrogen content of a coal upon its value as a steam producer.

Many large consumers of coal buy their fuel on the B.t.u. basis. In some instances, to form a correct estimate of the efficiency of coal as a steam producer, the ordinary method of estimating the value directly from the heat measurements made with a calorimeter should be modified.

Influence of Ash

There is little doubt that furnace efficiency is greater with low-ash than with high-ash fuel. This is partly explained in that the combustible loss in the refuse dropping to the ashpit is proportionately greater with the higher percentages of ash in the coal. In every furnace the ideal is to burn out all of the combustible, but with coal in the usual form this is never attained in commercial practice. When most of the combustible is consumed, the remainder is so inclosed or so intimately combined with the slag that it is difficult for the air to unite with it for combustion. Therefore, complete burning would necessitate keeping dead fuel on the grates for an abnormally long time. Grates so occupied would produce little or no steam, while the air drawn through the fuel bed would do little but cool off the furnace, thus reducing the steaming capacity and the efficiency. Consequently, the fires must be cleaned in such manner that even under the most careful operation some combustible will be rejected to the ashpit.

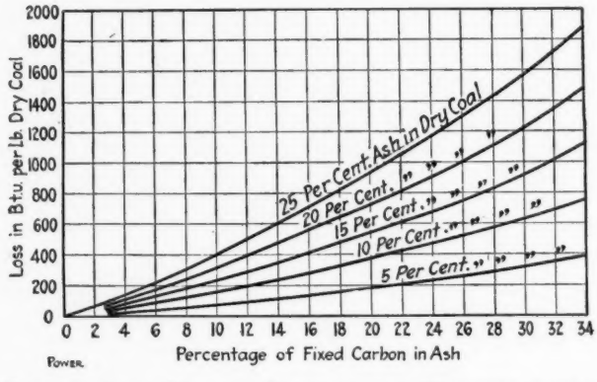


Fig. 1. Loss Due to Combustible Falling through Grate

In general, the completeness with which the combustible may be burned economically depends upon the design of the furnace and the grate as well as the nature of the coal. Records of ash analyses for well operated plants and covering long periods of time generally show that the standard of proper carbon content in the ash discharged from a certain type of furnace and grate is well defined. Accordingly, the greater the percentage of ash, the greater the amount of combustible rejected to the ashpit.

Fig. 1 shows the losses due to combustible discharged to the ashpit. For every pound of dry coal fired, the fraction of a pound of carbon lost to the ashpit equals

$$\frac{A}{100 - C} - \frac{A}{100} = \frac{C \times A}{100\ (100 - C)}$$

where

A = Percentage of ash in the dry coal;
C = Percentage of carbon in the ashes

The number of B.t.u. lost per pound of dry coal equals

$$14{,}600 \times \frac{C \times A}{100\ (100 - C)}$$

For example, assume 20 per cent. as the standard for carbon in the ash. With a coal containing 6 per cent. of ash and having a heat value of 14,600 B.t.u. per lb., the heat lost per pound of dry coal fired equals

$$\frac{14{,}600 \times 20 \times 6}{100\ (100 - 20)} = 219\ B.t.u.$$

and the percentage loss equals

$$\frac{219 \times 100}{14{,}600} = 1.5\ per\ cent.$$

With 12 per cent. ash, the loss equals 438 B.t.u. and the percentage is 3.

Besides fixed carbon, the refuse usually contains a small amount of volatile matter which can be neglected in ordinary calculations. The loss due to sensible heat in the red-hot ashes is almost negligible, being less than 0.5 per cent. with coals of less than 15 per cent. ash.

Moisture in the Coal

Water in coal must be evaporated and superheated to the flue temperature at atmospheric pressure. Thus, heat must be rejected to the chimney, and hence moisture in

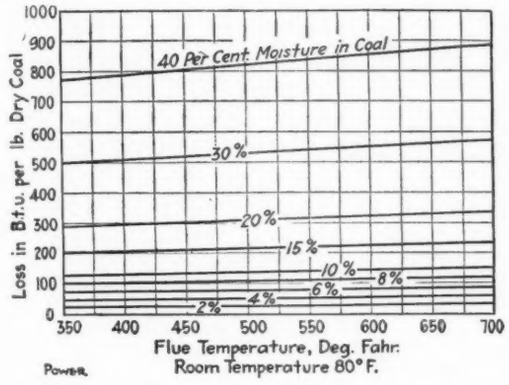


Fig. 2. Loss Due to Moisture in Coal

coal, in addition to being a dead weight, is an active heat waster.

The B.t.u. lost per pound of dry coal equals

$$\frac{M \times (H - t + 32)}{100 - M}$$

where

M = Percentage of moisture in the coal as fired multiplied by 100 and divided by the difference between 100 and the percentage of moisture;

H = Total heat in 1 lb. of steam at atmospheric pressure and the temperature of the flue gases;

t = Room temperature.

For illustration, assume a coal of 14,000 B.t.u. (dry basis), 4 per cent. moisture, 80 deg. room temperature and 500 deg. stack temperature. The heat loss would be

$$\frac{4.2\ (1285 - 80 + 32)}{100 - 4.2} = 54\ B.t.u.$$

Fig. 2 shows the loss due to moisture. The percentage of loss is usually insignificant, being for the case given

$$\frac{54 \times 100}{14{,}000} = 38.5\ per\ cent.$$

Influence of Hydrogen in Coal

A pound of hydrogen burned in an inclosed calorimeter will produce 62,000 B.t.u. Therefore, other things being equal, the richer the coal is in hydrogen, the higher its heat value. In a bomb calorimeter, the water which results from the burning of the hydrogen with oxygen is condensed and its latent heat thus given up is credited to the coal; but in an open furnace, this heat, together with that required for superheating from the temperature due to atmospheric pressure to the flue temperature, is wasted. Therefore, to estimate the true available heat of the coal, a deduction, depending upon the percentage of hydrogen, should be made from the calorimeter value.

When a pound of hydrogen burns, 9 lb. of water is formed. Therefore, when a pound of hydrogen burns, the heat necessary to evaporate superheat, 9 lb. of water is lost to the stack. This loss in B.t.u. per pound of dry coal equals

$$\frac{9 \times Hy \times (H - t + 32)}{100}$$

where Hy = Percentage of hydrogen in the dry coal;
H *and* t = Same as before.

For illustration, assume a coal of 14,000 B.t.u., containing 5 per cent. hydrogen, a room temperature of 80 deg. and a stack temperature of 500 deg. The loss per pound of dry coal equals

$$\frac{9 \times 5 \times (1285 - 48)}{100} = 557\ B.t.u.$$

and the percentage of loss equals

$$\frac{557 \times 100}{14{,}000} = 4\ per\ cent.$$

It will appear from the foregoing that a comparison on a straight B.t.u. basis of calorimeter values between an anthracite containing 2 per cent. of hydrogen and a

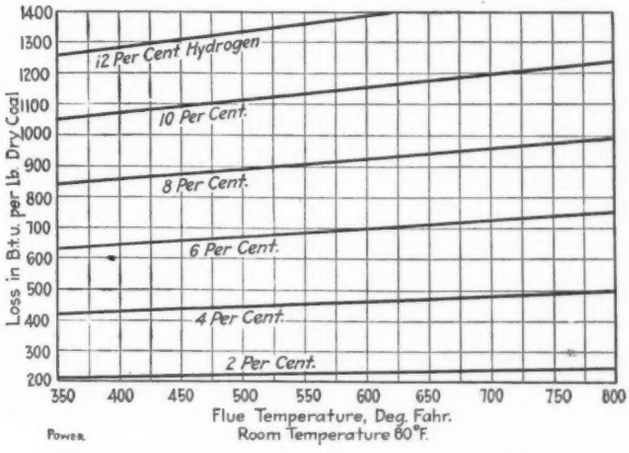


Fig. 3. Loss Due to Hydrogen in Coal

bituminous coal containing 5 per cent. of hydrogen is erroneous.

Fig. 3 shows the loss due to hydrogen in different percentages. It is, moreover, entirely possible for several coals to show the same value in the calorimeter and yet differ as much as 3 or 4 per cent. in actual commercial value as steam producers.

A General-Utility Machine, says "Popular Mechanics" for office buildings, apartment houses, and small shops is now on the market, which is so adapted that its uses are manifold. Seventy-seven tools, so the manufacturers say, may be operated by this one handy contrivance. A friction-drive handle with flexible shaft attached to ¼- or ½-hp. motor, gives a speed of from 1650 to 2700 r.p.m.

Chalk Briquettes as Fuel in England—The Leeds briquette works at Hunslet has recently been making experiments to determine the possibility of the use of chalk briquettes for fuel. It is said that the company is able to obtain its chalk in the south of England at a cost of from 14 to 25c. per ton, and that it is proposed to sell it in briquette form at from $3.75 to $5 per ton. The briquettes are 5 in. long, 4 in. wide and 2½ in. thick. It is claimed that they burn with little or no smudge, with an exceedingly small amount of ash, and that they give off from 40 to 50 per cent. less smoke than coal. If the idea should prove as successful as seems posible from the foregoing it will be a large step toward the solution of the smoke problem.

Useful Boiler Tables

ALLOWABLE LOADS ON STANDARD WROUGHT-IRON BOLTS FITTED WITH NUTS FOR VARIOUS SAFE STRESSES PER SQUARE INCH

Top	Diameter at Root	Threads per In.	Area at Root	5,000	6,000	6,500	7,000	7,500	8,000	9,000
¼	0.38	13	0.12	580	696	754	810	870	928	1,044
7/16	0.44	12	0.15	750	900	975	1,050	1,125	1,200	1,350
½	0.49	11	0.19	930	1,122	1,215	1,310	1,403	1,496	1,683
9/16	0.60	10	0.28	1,410	1,698	1,840	1,980	2,123	2,264	2,547
⅝	0.71	9	0.39	1,970	2,364	2,560	2,760	2,955	3,152	3,546
1	0.81	8	0.52	2,600	3,108	3,367	3,630	3,885	4,144	4,662
1⅛	0.91	7	0.65	3,250	3,906	4,232	4,560	4,883	5,208	5,859
1¼	1.04	7	0.84	4,200	5,046	5,467	5,900	6,308	6,728	7,569
1⅜	1.12	6	1.00	5,000	6,000	6,500	7,000	7,500	8,000	9,000
1½	1.25	6	1.23	6,140	7,368	7,982	8,600	9,210	9,824	11,052
1⅝	1.35	5½	1.44	7,180	8,616	9,334	10,000	10,770	11,488	12,924
1¾	1.45	5	1.65	8,250	9,906	10,731	11,560	12,383	13,208	14,859
1⅞	1.57	5	1.95	9,800	11,700	12,675	13,640	14,625	15,600	17,550
2	1.66	4½	2.18	10,900	13,080	14,170	15,260	16,350	17,440	19,620
2¼	1.92	4½	2.88	14,400	17,280	18,720	20,180	21,600	23,040	25,920
2½	2.12	4	3.55	17,730	21,300	23,075	24,830	26,625	28,400	31,950
2¾	2.37	4	4.43	22,150	26,580	28,885	31,000	33,225	35,504	39,942
3	2.57	3½	5.20	26,000	31,200	33,800	36,360	39,000	41,600	46,800

Use 8000 lb. for Massachusetts under 1¼-In. Use 6000 Lb. for Bolts on Removable Heads.

ALLOWABLE LOADS ON STAYBOLTS, 12 THREADS PER INCH, FOR VARIOUS SAFE STRESSES PER SQUARE INCH

Top	Diameter Root	Area at Root	6000	6500	7000	7500	Top	Diameter Root	Area at Root	6,000	6,500	7,000	7,500
¾	0.6057	0.288	1729	1872	2016	2160	1 1/16	1.1682	1.072	6,432	6,968	7,504	8,040
13/16	0.6682	0.351	2016	2282	2457	2632	1⅛	1.2307	1.190	7,140	7,735	8,330	8,925
⅞	0.7307	0.419	2514	2724	2933	3142	1 3/16	1.2932	1.313	7,878	8,535	9,191	9,848
15/16	0.7932	0.494	2964	3211	3458	3705	1¼	1.3557	1.444	8,664	9,386	10,108	10,830
1	0.8557	0.575	3454	3738	4025	4313	1 5/16	1.4182	1.579	9,474	10,263	11,053	11,843
1 1/16	0.9182	0.662	3972	4303	4635	4965	1⅜	1.4807	1.721	10,326	11,186	12,047	12,908
1⅛	0.9807	0.755	4530	4908	5285	5663	1 7/16	1.5432	1.870	11,220	12,155	13,090	14,025
1 3/16	1.0432	0.855	5130	5558	5985	6413	1½	1.6057	2.024	12,144	13,156	14,168	15,180
1¼	1.1057	0.960	5760	6240	6720	7200	1 9/16	1.6682	2.185	13,110	14,203	15,295	16,388

Use 6000 lb. U.S.G. Indiana and Chicago. Use 7000 lb. Massachusetts and Ohio 1¼ in. and over. Use 6500 lb. Massachusetts and Ohio under 1¼ in. Use 7500 lb. for Philadelphia, Pa.

ALLOWABLE PRESSURES PER SQUARE INCH FOR STAYBOLTED FLAT PLATES OF VARYING PITCH AND THICKNESS

Thick In.	Maximum Pitch in Inches: 4	4⅛	4¼	4⅜	4½	4⅝	4¾	4⅞	5	5⅛	5¼	5⅜	5½	5⅝	5¾	5⅞	6	6¼	6½	6¾	6½	6⅝	6¾	6⅞	7	7⅛	7¼	7⅜	7½	7⅝	7¾	7⅞	8
¼	165	149	136	125	115	107	99	93	86	81	76	72	68	64	61	57	55	52	49	47	45	43	41	40	38	36	35	34	32	31	30	29	28
5/16	237	215	197	180	166	154	143	133	125	117	110	103	98	92	87	83	79	75	71	68	65	62	60	57	55	53	51	49	47	45	43	42	40
⅜				227	210	195	182	170	160	150	141	133	126	119	113	107	102	97	93	89	85	81	78	75	72	69	66	64	62	59	57	55	
7/16								222	208	195	184	174	164	156	148	140	134	127	121	116	111	106	102	98	94	90	87	84	81	78	75	72	
½												220	206	197	187	178	169	161	154	147	141	135	129	124	119	114	110	106	102	98	95	92	
9/16																220	209	199	190	182	174	166	159	153	147	141	136	131	126	122	117	113	
⅝																				220	210	201	193	185	178	171	164	158	153	147	142	137	

Table calculated from Massachusetts formula, $P = \frac{66\,(t+1)^2}{S^2 - 6}$, in which P = lb. per sq.in. S = max. pitch, t = thickness in 16ths, 66 = constant.

EFFICIENCIES OF DOUBLE RIVETED LAP JOINTS

Tensile Strength = 55,000 Lb. per Sq.In. Shearing Strength of Rivets = 42,000 Lb. per Sq.In.

Pitch, In.	Hole, In.	Thickness of Plate ½	7/16	⅜	5/16	¼
2	1	50.0	50.0	50.0	50.0	50.0
	1 1/16	53.1	53.1	53.1	53.1	53.1
	1⅛	56.2	56.2	56.2	56.2	56.2
	1 3/16	59.3	59.3	59.3	59.3	59.3
	1¼	62.5	62.5	62.5	62.5	62.5
	1 5/16	56.7	64.7	65.6	65.6	65.6
2¼	1	53.0	53.0	53.0	53.0	53.0
	1 1/16	55.9	55.9	55.9	55.9	55.9
	1⅛	58.8	58.8	58.8	58.8	58.8
	1 3/16	61.8	61.8	61.8	61.8	61.8
	1¼	63.5	64.7	64.7	64.7	64.7
	1 5/16	53.4	61.0	67.6	67.6	67.6
2½	1	55.6	56.6	55.6	55.6	55.6
	1 1/16	58.3	58.3	58.3	58.3	58.3
	1⅛	61.2	61.2	61.2	61.2	61.2
	1 3/16	64.9	64.9	64.9	64.9	64.9
	1¼	60.0	66.6	66.6	66.6	66.6
	1 5/16	50.4	57.6	67.2	69.4	69.4
2¾	1	57.8	57.8	57.8	57.8	57.8
	1 1/16	60.6	60.6	60.6	60.6	60.6
	1⅛	63.2	63.2	63.2	63.2	63.2
	1 3/16	65.7	65.7	65.7	65.7	65.7
	1¼	56.8	65.0	68.4	68.4	68.4
	1 5/16	47.8	54.6	62.6	71.1	71.1

Pitch, In.	Hole, In.	Thickness of Plate ¾	11/16	⅝	9/16	½	7/16	⅜	5/16	¼
3	1¼	58.3	56.3	56.3	56.3					
	1 5/16	60.4	60.4	60.4	60.4					
	1½	62.5	62.5	62.5	62.5					
	1 7/16	60.4	64.6	64.6	64.6	64.6				
	1	53.3	58.2	63.9	66.6	66.6	66.6	66.6	66.6	66.6
	1⅛			56.4	68.8	68.8	68.8	68.8	68.8	68.8
	1¼				54.3	61.3	70.0	71.0	71.0	71.0
	1⅜					52.8	60.4	70.4	72.9	72.9
	1½					45.0	51.4	60.0	72.0	75.0
	1⅝					37.8	43.2	50.4	60.5	75.6
3¼	1¼	61.5	61.5	61.5	61.5					
	1 5/16	63.4	63.4	63.4	63.4					
	1½	62.2	65.4	65.4	65.4					
	1 7/16	55.5	60.6	66.7	67.3	67.3				
	1	49.2	53.7	59.1	65.6	69.2	69.2	69.2	69.2	69.2
	1⅛			51.9	57.8	65.0	71.2	71.2	71.2	71.2
	1¼				50.3	56.6	64.7	73.1	73.1	73.1
	1⅜					48.8	56.7	65.1	75.0	75.0
	1½					41.5	47.4	55.4	66.4	76.9
	1⅝					34.9	39.9	46.5	55.8	69.8

Pitch, In.	Hole, In.	Thickness of Plate ¾	11/16	⅝	9/16	½	7/16	⅜	5/16	¼
3¼	1¼	62.9	62.9	62.9	62.9					
	1 5/16	64.8	64.8	64.8	64.8					
	1½	60.0	65.6	66.4	66.4					
	1 7/16	53.6	58.5	64.2	68.4	68.4				
	1	47.4	51.8	56.9	63.2	70.3	70.3	70.3	70.3	70.3
	1⅛			50.0	56.6	62.5	71.5	72.2	72.2	72.2
	1¼				48.4	54.5	62.3	72.7	74.1	74.1
	1⅜					46.9	53.7	62.6	75.1	76.1
	1½					40.0	45.7	53.4	64.0	77.7
	1⅝					33.6	38.4	44.8	53.7	67.2
3½	1¼	64.2	64.2	64.2	64.2					
	1 5/16	64.5	66.1	66.1	66.1					
	1½	57.8	63.2	67.9	67.9					
	1 7/16	51.7	56.4	61.9	68.8	69.6				
	1	45.8	49.9	54.8	60.9	68.6	71.5	71.5	71.5	71.5
	1⅛			48.2	53.6	60.2	68.9	73.3	73.3	73.3
	1¼				46.7	52.5	60.0	70.0	75.0	75.0
	1⅜					45.2	51.7	60.4	72.5	76.8
	1½					38.5	44.1	51.4	61.7	77.1
	1⅝					32.4	37.0	43.2	51.8	64.8

Plate Failures

Rivet Failures

Courtesy of the Boiler Inspection Department of the Fidelity & Casualty Company of New York

Calculating Heat Losses from Buildings

By Charles L. Hubbard

The first step in the consideration of any system of warming, whatever its type, is to determine the heat loss from each room in B.t.u. per hour. This depends upon the character and extent of the exposed surface, the difference between the inside and outside temperatures, and the points of the compass.

The buildings considered in the present article may be included in four general classes, according to their construction and heat requirements. Class 1 includes office and municipal buildings, hotels, hospitals, theaters, schools, loft buildings, etc., where the walls are constructed of brick or stone with an inside furring of lath and plaster, and in which a normal temperature of 70 deg. is desired.

Class 2 includes shops and factories of brick or concrete, without furring, usually several stories in height, and also requiring a temperature of 70 deg.

Class 3 includes shops of modern design having walls of brick or concrete and thin roofs of different construction. Buildings of this type are usually heated to 60 deg.

Class 4 includes foundries, boiler and forge shops, etc., covered entirely, or in part, with corrugated iron, and heated to 50 deg.

These different classes of buildings will now be taken up in order, with tables and data for computing the heat loss from each within the usual range of conditions.

Class 1. For buildings in this class, the following data may be used:

TABLE 1. (WALL SURFACE). HEAT LOSS IN B.T.U. PER SQ.FT. OF SURFACE PER HR. FOR A TEMPERATURE DIFFERENCE OF 70 DEGREES

Solid Brick Wall with Lath and Plaster Furring and Air Space	Heat Loss in B.t.u.
8-in. brick	18
12-in. brick	16.5
16-in. brick	15
20-in. brick	12.5
24-in. brick	11
28-in. brick	10

For brick walls with sandstone face, 4 to 8 in. in thickness, plastered inside, but without furring or air space, multiply the factors in Table 1 by 1.3. For stone walls instead of brick, multiply the factors in the table by 1.3.

TABLE 2. (GLASS SURFACE). HEAT LOSS IN B.T.U. PER SQ.FT. OF SURFACE PER HR. FOR A TEMPERATURE DIFFERENCE OF 70 DEGREES

Character of Surface	Heat Loss in B.t.u.
Single sash	84
Double sash	42
Single skylight	91
Double skylight	46

For other temperature differences than 70 deg., multiply the factors in Tables 1 and 2 by the following: For 50 deg. multiply by 0.71; 60, 0.86; 70, 1; 80, 1.14; 90, 1.30.

In addition to the heat loss by transmission there is also a certain amount due to leakage, depending upon the tightness of the building construction, especially around doors and windows. This may be provided for in the average well built structure by multiplying the transmission loss by 1.2. For public rooms, where there is a good deal of passing in and out, it will be necessary to use a larger factor, depending upon local conditions. In main lobbies and similar rooms, a factor of 1.5 to 2 is often required.

Corrections for different points of the compass should be made as follows: For north exposure, multiply by 1.3; east, 1.1; south, 1; west, 1.2.

In rooms of considerable height, the heat loss is increased on account of the higher mean temperature and the more rapid circulation of the air over the cool surfaces. This amounts to about 2 per cent. for each additional foot above 12 ft. in height.

Although in office buildings the walls are reduced in thickness on the upper floors, it is not usually necessary to enlarge the radiators on this account, because the warm air, rising, is generally sufficient to offset any increase in heat transmission due to this cause. For very tall buildings, however, where the upper floors are more exposed to the wind, it may be necessary to allow for the thinning of the walls and also increase the factor for leakage.

When there is a low attic or roof space in which steam pipes are carried, no additional radiation is required to offset a cold ceiling on the upper story. In case of a roof space without steam pipes, increase the radiation about 15 per cent. When there is a solid roof, without air space, use the factor from Tables 4 or 6, which corresponds most nearly to the actual conditions.

Example: A room in an office building has a wall exposure of 450 sq.ft. and a glass exposure of 100 sq.ft. The walls consist of 8 in. of brick, with sandstone facing, plastered on the inside. The windows have single sashes, and the exposure is east. What will be the total heat loss per hour for a temperature difference of 70 deg.?

Factor for wall, 18 × 1.3	=	23.4
Factor for window	=	84
Factor for leakage	=	1.2
Factor for exposure	=	1.1

from which the total heat loss is found to be

$$[(450 \times 23.4) + (100 \times 84)] \times 1.2 \times 1.1 = 24{,}987 \text{ B.t.u.}$$

Class 2. Buildings of this type are usually of solid brick or of concrete, without insulating finish of any kind upon the inside walls, except in special rooms, such as offices, drafting rooms, etc.

TABLE 3. (WALL SURFACE). HEAT LOSS IN B.T.U. PER SQ.FT. OF SURFACE PER HR. FOR A TEMPERATURE DIFFERENCE OF 70 DEG.

		Heat Loss in B.t.u.
Solid walls,	8-in. brick	31
	12-in. brick	22
	16-in. brick	18
	20-in. brick	15
	24-in. brick	14

For reinforced concrete, multiply the factors in Table 3 by 1.3. For ordinary wooden construction, with paper and clapboards on the outside and lath and plaster on the inside, use a factor of 21 for a temperature difference of 70 deg. For roof construction of different kinds, use Table 4.

TABLE 4. (ROOF SURFACE). HEAT LOSS IN B.T.U. PER SQ.FT. OF SURFACE PER HR. FOR A TEMPERATURE DIFFERENCE OF 70 DEG.

Roof Construction	Heat Loss in B.t.u.
Slate on matched boards	21
Iron on matched boards	12
8-in. hollow tile, 1-in. concrete, tar and gravel	28
6-in. concrete, cinder fill, tar and gravel	38

For window surface, see Table 2.

With wooden sashes the factor for leakage may be taken as 1.3, while for iron sashes, which are much tighter, it may be reduced to 1.10.

In shops and factories where the floors are undivided by partitions, and the walls exposed to all four points of the compass, a factor of 1.16 may be used when correcting for exposure.

For other temperature differences than 70 deg., use the factors given under Class 1.

Class 3. The conditions here are much the same as in Class 2, except that the entire building is treated as a single room and a lower inside temperature is maintained.

TABLE 5. (WALL SURFACE). HEAT LOSS IN B.T.U. PER SQ.FT. OF SURFACE PER HR. FOR A TEMPERATURE DIFFERENCE OF 60 DEG.

		Heat Loss in B.t.u.
Solid walls,	4-in. brick	40
	8-in. brick	26
	12-in. brick	19
	16-in. brick	16

For reinforced concrete, multiply the factors in Table 5 by 1.3.

TABLE 6. (ROOF SURFACE). HEAT LOSS IN B.T.U. PER SQ.FT. OF SURFACE PER HR. FOR A TEMPERATURE DIFFERENCE OF 60 DEG

Roof Construction	Heat Loss in B.t.u.
Patent roof (tar and gravel)	18
6-in. hollow tile, 2-in. concrete, tar and gravel	22
4-in. concrete, cinder fill, tar and gravel	36
Unlined metal	78

For tile and concrete floors on earth, use a transmission factor of 6 for ordinary conditions.

For single windows, and a temperature difference of 60 deg., use a transmission factor of 72.

Leakage may be treated the same as in Class 2, using the factors 1.3 and 1.1 for wooden and iron sash, respectively.

The factor for exposure may be taken as 1.16, considering the whole building as a single room.

Class 4. Buildings of this type are confined chiefly to foundries, boiler shops, forge shops, etc., where the normal inside temperature may be comparatively low. Tests show that the transmission losses through unlined corrugated metal are nearly the same as for a single window, and for all practical purposes no distinction need be made between the walls, windows or roof in buildings of this kind.

Taking the transmission factor as 65 for a temperature difference of 50 deg., and multiplying by 1.3 and 1.16 for leakage and exposure, respectively, gives a total loss of

$$65 \times 1.3 \times 1.16 = 98.02 \ B.t.u.$$

per square foot of gross area per hour. To this should be added a transmission of about 5 B.t.u. per square foot of floor area.

In general, a heat loss of 100 B.t.u. per square foot of gross wall and roof area will safely cover all ordinary conditions where the outside temperature does not drop much below zero.

Odd Ammonia-Condenser Trouble

By A. G. Solomon

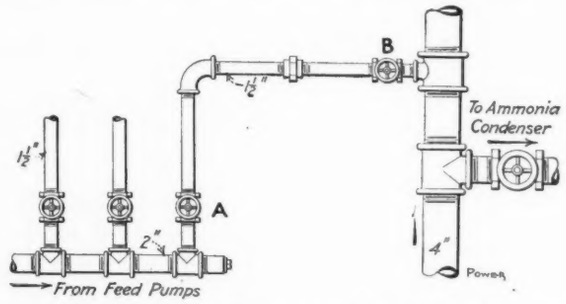
While overhauling an ice plant, it was found necessary to do some work on the boiler-feed pumps and heaters. While this was being done, the boilers were supplied with cold water direct from the pumps that were used to circulate water through the double-pipe ammonia condensers.

The pipe arrangement is shown in the illustration. The boiler-feed pumps discharged into a manifold from which a feed line extended to each boiler, and the feed valves were so placed as to be easily reached. To make a neat job the cold-water line was connected into the manifold and extended upward as did the feed lines to the boilers. The other end of this line was connected close to the pipe that supplied water to the ammonia condenser. A valve was placed at each end of this temporary feed line, that at the manifold being located in the same relative position as was the regular boiler-feed valves.

During the time this temporary line was in use, the ice machines were not needed, so the line answered the purpose, as the condenser pumps were designed for high-pressure service and they easily pumped into the boilers. When we were ready to use the regular feed pumps and heater again, we shut the valves *A* and *B*, and fed through the other feed lines.

One day the condenser pressure began to rise in jumps. One ice machine was immediately shut down, but still the pressure increased. The other machine was stopped, but the pressure remained much above where it should be; in fact, it kept slowly going still higher. To relieve the condenser, the expansion valves on the ice tanks were opened wide and the ammonia allowed to go into the coils.

What had caused the sudden raise of pressure puzzled all. On going outside to the condenser it was found that the coils were hot. Then the fireman located the trouble. He had opened the valve on the cold-water line at the manifold by mistake and we found that the valve on the other end of this line had become open a few turns by the jar set up by the pumps. After closing both valves tight we started one of the ice machines. During the time that the condenser pressure was high and the expansion valves were open, much liquid got into the coils in the ice tanks. It took over an hour of "pumping down," with the machine running slowly to get rid of the liquid and allow of starting the other machine. The cold-water feed line was disconnected at a union and the two ends left open.



Connection between Feed and Ammonia Condenser Mains

Editorials

The Power-Plant Arteries

Considering the amount of pipe work, especially for steam, that has been done since high pressures become common, one wonders at the large number of accidents still occurring yearly, due to defective work. Enough has been said in the engineering press, and discussion among engineers has been sufficiently widespread, to insure that all interested may obtain adequate and trustworthy information relative to the proper arrangement for piping for various conditions. With all the recorded information available, however, there is much piping so put up as to be dangerous. It is certain, therefore, that it is the human element which is at fault in this as in so many other channels of effort.

The most common defect is improper provision for draining the lines of condensate. It is fortunate that a poorly designed piping layout may be made safe usually if one will take the trouble to put in enough drain lines, place them where they belong, and provide reliable traps.

Just as a proper condition of arteries of the body is essential to the health and even the life of living beings, so, too, must the power-plant arteries be right for the sake of the safety of the equipment and those who care for it.

Make the piping right; it pays.

Burning Soft Coal without Smoke

During recent years there has been a great deal of agitation over the question of smoke in the larger cities of the country. Ordinances have been passed and enforced to a degree permitted by the slow working of the courts. Campaigns of education have been started and in most cases have done more good than the fines imposed, as those violating the ordinances were shown how to eradicate the evil and to use firing methods conducive to smokeless operation. Progress has necessarily been slow, as each installation formed an individual problem which had to be solved under the conditions existing.

To more successfully reduce the smoke nuisance, departures from standard furnaces were made. The results were carefully watched and improvements effected until new designs were evolved, which may appear radical to the conservative observer. For different kinds of fuel, varying rates of combustion and distinctive types of boiler, the modifications are many and have necessitated much original work and close observation by the personnel of the various smoke departments.

Chicago has been a leader in this new work. At one time it produced enormous quantities of heavy, black smoke, and more soot to the square foot than any other city in the country, with perhaps one or two exceptions. This was due to the improper burning of a fuel which, for the most part, was bituminous coal of a highly volatile character. Due to the large number of railroads and other causes, the conditions are not yet ideal, but they are greatly improved.

During the past seven years the Chicago Smoke Department has had a corps of mechanical engineering experts engaged in the practical work of smoke suppression and it has collected an enormous amount of data. Starting with the last issue, the results of this work are to be given in POWER in a long series of articles written by the chief smoke inspector. It will be his endeavor to present the material in a simple manner, showing good practice in furnace design and in methods of burning from the standpoint of actual experience in the field.

While the average consulting engineer may have details of a half-dozen boiler plants in his office in a year, the Chicago Department of Smoke Inspection in the same period passes on upward of five hundred distinct plants, aggregating from one thousand to one thousand two hundred separate boilers. These installations, when completed, operate under the eyes of the mechanical engineers in the department and valuable experience is thereby collected, showing what a steam plant will do in actual service.

The series starts with an analysis of the gas passes, grate surface, damper areas, breeching areas and stack height and section in relation to the best practice from the standpoint of smokeless operation. After these subjects have been covered, the actual designs of furnace will be taken up, commencing with hand-fired furnaces and horizontal return-tubular boilers. Hand-fired furnace development will be outlined with special reference to the burning of Illinois bituminous coals, and the reasons for the final adoption of the furnaces now in vogue will be considered. Hand-fired furnaces in connection with water-tube boilers for burning coal or mixed fuels, such as wood refuse and sawdust, will then be given attention.

Stokers for different types of boiler will be discussed and working drawings shown of actual settings known to be successful. The series will continue with the consideration of mechanical stokers alphabetically, commencing with the chain grate. The articles will deal with all kinds of boilers on the American market and show how the different types of stoker can be made to give satisfactory results. Most of the illustrations will be working drawings, indicating how each setting was installed, and the selection of the different types of setting will be from those most successful under the observation of the author. In this way a large number of smokeless settings will be shown, so that the series should be of great value to the consulting engineer, the operating engineer and the fireman.

A large part of the smoke inspector's work is to clean up existing settings installed under adverse conditions, such as low headroom, small floor space and the limits to excavation due to floating foundations and the inadvisability of going below the sewer level. A special series will be devoted to many installations made successful under these adverse conditions.

The man in the plant should know how to burn his fuel smokelessly, what type of hand-fired furnace or stoker is best adapted to his work, how the boiler should be baffled, the proper draft for different rates of combustion, the best type of damper and where to locate it, and many other things which will enable him to operate his boilers to the best advantage and without smoke. When the fuel is bituminous coal or wood refuse, this series will give this information. The treatment is simple and direct and not over the head of the average fireman. The combined work of a progressive department covering a period of seven years should be worth a great deal. It will pay to follow the series closely and give every article the attention it deserves.

A Comparison of Boiler Standards

Both Canada and the United States are giving increasing attention to regulations governing the construction of steam boilers. The comparison of the standards put forward by the Canadian provinces and by Massachusetts, the latter as representing the best of our practice, beginning on page 698, of this issue, will be found especially interesting and instructive. Analytical study to determine the best of the existing laws as models for future legislation may be made with profit by such of the states as have yet to enact statutes for safer boiler operation.

Some important differences in the requirements imposed by the Canadian provinces and by Massachusetts deserve further comment. First, with regard to the approval of designs, more might be said concerning the Canadian practice of approving the design in advance of construction, instead of leaving the manufacturers to interpret the rules at their own risk. When a Canadian manufacturer has obtained the approval and registration of a design, he is reasonably sure that his completed boiler will pass inspection. It is merely incumbent upon him to follow faithfully his drawings and specifications covering both the design and the workmanship. On the other hand, the manufacturer building his first boiler of any given type for use in Massachusetts, must wait until its completion before he knows that it is acceptable. It can easily be seen that the Canadian procedure is likely to save loss of time and of money for the manufacturer.

Mr. Macdonald, the author of our comparison, makes the point that the five- or ten-dollar fee charged for approving and registering a design in Canada conduces to standardizing practice to fewer designs. We should hardly credit the size of the fee as enough to have much influence in this direction, but we do believe that the trouble and time and other expenses involved in securing a registration will have a tendency to avoid a multiplicity of designs. At the same time, the Massachusetts practice may have an even greater effect of the kind, for a boiler builder, having gone through the experiment of learning what form of design when finished will pass, is likely to depart as little from it as possible in his subsequent product and other manufacturers are likely to imitate his successful design.

In the methods of stamping and identifying we should regard the form required by Alberta, Canada, better than that of Massachusetts, in that it gives more particulars. Simplicity is desirable and the Massachusetts marking may cover the essentials, but one can readily conceive of instances, however few, that might justify the little added effort required to supply the extra information given on the Canadian stamp. For one thing, the recording of the grade and the make of the plate impresses the makers of both the boiler and the plate with the need of using proper material. The plate maker in particular feels his responsibility when the plate is identified as his.

We indorse that provision in Canada of a stamp "For Heating Purposes Only" on all heating boilers. Like the label "For External Use Only." on packages containing liniments or poisonous drugs, it makes it a clear case of attempted suicide to misapply the article marked.

As to the different ways of determining the factor of safety, the Canadian way may be more thorough, but it is also more complicated. A striving for such scientific exactness in the prescription for the factor of safety when so many variable factors are to enter later, such as unknown defects in material, individual workmen's differences in workmanship and individual inspectors' differences in judgment, would seem futile. It strikes us as about as justifiable as weighing the coal and water for a boiler test to fractions of an ounce when the condition of the fire and the level of the water in the boiler at the beginning and end of the test are judged by the eye. In working up the results of a test where countless errors can enter in, the final figures are apt to be as accurate when a slide rule is used as when the calculations are all carried out to the sixth decimal place.

The factor of safety, or "factor of ignorance," as it is sometimes called, is a guess anyhow, and we venture that a Yankee can guess according to the Massachusetts method with equal closeness.

Some advantages may attend the use of rules covering the design of riveted joints to the greater detail followed in Canada than in Massachusetts. It tends to uniformity in the practice of different manufacturers and, as Mr. Macdonald says, "discourages freak joints." We are not prepared to admit, however, that it is advisable not to allow the manufacturer enough latitude to enjoy the fruit of his experience by employing such joints as he has found best for given purposes. Manufacturers of limited competence will be protected against their own shortcomings by the Canadian rules, but who can say that the makers of rules are always better qualified than the builders of boilers to know what is right? If rules are drawn up, as they should be, in conference with the best talent in the boiler-making business, and the recommendations of the latter are embodied, they will be sufficiently comprehensive. The same applies whether they are for joints, stayed surfaces, cylindrical shells or for heads.

Our principal concern is not with the minutiæ of the rules and regulations governing boiler construction as now in force in certain of the provinces and states; they can work out their own salvation. What we earnestly ask is that more provinces and more states will adopt rules of some kind. Anything is better than nothing, and too many commonwealths have no boiler laws.

The "Useful Boiler Tables" on page 706 were compiled by and for the Boiler Inspection Department of the Fidelity & Casualty Company of New York to which we are indebted for the privilege of presenting them in our pages. While primarily for the convenience of boiler inspectors, they are obviously handy for any one having to do with boilers.

Correspondence

Getting Rope to Top of Stack

In the Feb. 10 issue a letter told how to get a rope over the top of a chimney. It reminds me of a similar job done on an 80-ft. steel stack preparatory to painting it. There was no pulley on top, and as it was in service it was impossible for the painter to get up through the inside.

The guy ropes which held the stack were fastened 12 ft. below the top. To get a rope to the top of the stack the following means were adopted. A steel cable with a shackle at one end was put completely around the outside of the guy ropes, forming a circle. The loose end was passed through the shackle as a rope passes through an eye. To the shackle a pulley block having a long rope attached to a bosn's chair was hooked. By pulling on the loose end of the shackle rope, that rope and the pulley were pulled up over the guy ropes until they reached the point 12 ft. from the top of the stack. Then the loose end was made fast to prevent the shackle rope from slipping down over the guys. The bosn's chair was then hoisted, the painter sitting in it and having a 15-ft. pole to which was hooked a roped pulley block having a hook which the painter slipped over the top of the stack with the aid of the pole. The bosn's chair was then made fast to the second rope and the painting of the stack begun.

W. A. Cooil.

Ladysmith, B. C., Can.

Boiler Settings

The horizontal return-tubular boiler is the most widely used in the United States, and the setting usually provided is about the same in general design in all sections of the country. There are two main faults generally to be found with the setting used for such boilers, the first being that they are almost always set too low. The cause of this error probably originated and was perpetuated owing to a misconception of the true principles involved in efficient furnace performance and because of the extra cost involved in setting such boilers high. After all that has been said about the theoretical and the practical requirements for economical furnace performance, there are few uptodate engineers who will contend that the added cost to the boiler setting, and possibly the boiler house, required to set boilers a sufficient distance above the grate to procure good combustion, is not warranted.

Another feature which is usually wrong with such boiler settings is that the walls are nearly always built with air spaces in them. Probably no water-tube boiler today has its setting arranged with air spaces left in the walls, because their settings are relatively high, and if the attempt were made to leave air spaces in such walls, when built of the usual thickness, they would probably fail in use.

No one has ever advanced a reasonable theory for the use of an air space in setting walls, but there are many good reasons why they should not be used. In the first place, as pointed out, they weaken the walls. Another thing, of much importance, is that the air space permits the leakage of outside air to the furnace and the combustion chamber. No engineer would think of covering a steam pipe with a sheet-metal tube larger than the pipe and passing air through the annular space between the two to prevent radiation losses. Yet this is practically what is done in the case of the horizontal return-tubular boiler setting.

The "pull" of the stack produces a lower air pressure on all the inner surfaces of the setting than that exerted on the outer surfaces. This causes a constant leakage of air through all cracks and crevices, and even through the pores of the brick, and an air space in the wall necessarily promotes such leakage.

Some builders have gone so far as to leave openings in the outer walls of the setting and at the top of the walls to provide ready means for the air to reach this space, which seems ridiculous.

High settings built with solid walls, properly protected by means of plastic asbestos cement or otherwise to prevent air leakage, will prove a good investment for any plant. With the ever increasing vigilance of the smoke inspector, the high setting with tight walls will be required of the boiler user and in a manner similar to others of the past, economical conditions will be forced on him by outsiders who have no interest in the economical operation of his plant.

J. E. Terman.

Hartford, Conn.

Care of Boilers

In his letter in the Mar. 31 issue, page 454, H. H. Burley states that two water-tube boilers under his care have been run 19 years without having the pressure reduced by the police or the insurance authorities. This is a good record. Mr. Burley also says that each boiler is used for one month and then cut out of service for cleaning; a pressure of 100 lb. is carried.

I believe my two water-tube boilers have a record that beats Mr. Burley's. They were built in 1882, are of 75 hp. each, and carry a pressure of 80 lb., which has never been reduced. We run six days a week, 51 weeks a year, one week being set aside for general overhauling. Unlike Mr. Burley, we use a compound, but do not employ a mechanical cleaner in the tubes. Condensate or "returns" is not used, it being allowed to go to the sewer.

The boilers were originally fitted with cast-iron mud drums, but as one burst, both boilers were then equipped with steam drums.

I have had considerable marine experience and have seen boilers on shipboard that were 25 to 28 years old.

A. England.

New York City.

While the Chief Was Away

In the case cited in the letter under this title, in the Mar. 31 issue, many improvements were made and much money was saved by changes in plant operation during the absence of the chief engineer.

Undoubtedly, there are underlying causes of which we have no information. If the chief was above listening to suggestions from his subordinates, then the matter is understandable, but if he was not, why did not someone of the force bring these things to his notice? It is unreasonable to suppose that no one at the plant was aware of existing conditions, and it would have been but common honesty and loyalty, both to the chief and the company, to have reported them.

The statement about the dampers and the indicator in the engine room, which was supposed to tell when the dampers were closed, is interesting. Fancy a man being obliged to crawl inside the flue to find out what the dampers were doing when draft gages are so cheap and plentiful. When boilers are equipped with draft gages there is no need of a home-made telltale in the engine room.

An engineer in a large plant has little time to look after boiler-room matters. The better way is to have a capable man in charge of that department.

From the information published, it would seem that things were not uptodate in this plant, although steps seem to have been taken in the right direction.

I wonder why the master mechanic did not coöperate with the chief to the same extent that he did with the assistant chief and use a little team work.

WILLIAM PLAISTED.

Redondo Beach, Calif.

I contend it is necessary for the efficient operation of any power plant that the chief engineer treat his men with some consideration instead as mere laborers. To be successful, the chief must have the coöperation of his men. He may be forced to discharge a few at first, but if he will consult with his men occasionally, he may get ideas that will make his position easier.

Take, for instance, the case cited by Mr. Olliver. Had the chief been the kind of man to confide in, he would have learned of the assistant's idea to reduce the coal consumption, and could have accomplished the saving that was made while he was away. A chief should get all of the information out of his men that he can, but he should not act on their suggestions without giving them credit for the idea; that would be unfair.

Some time ago I read a description of the plant in one of the largest packing houses in the country and was impressed with the manner in which the engineers were made—"made" is the proper word—and treated. The chief is in consultation every morning with his assistants and they consult with the men in their departments concerning the work. This is a large company, and the men are promoted to a higher position whenever there is a vacancy or a new plant is started.

The men are required to study, and are sent to the various plants that they may become familiar with the work in all of them, so that in an emergency case they can be sent to any plant instead of hiring new men. This encourages them, and gives them an incentive to do their best.

Some engineers hold that if a chief became familiar with his men he would have trouble to get them to obey a disagreeable order, and that there would be no discipline. If a man gets the idea that because he is treated with respect he does not have to obey orders, he should be discharged. The plan as worked out by the company mentioned signifies that it is successful from the viewpoint of both sides.

Every man in the plant should be entitled to equal consideration, no matter what his position. When any complaint arises where the actions of one man are questioned by another, have both sides of the controversy present, and give each side a chance to prove his case. This will check the practice of tale bearing and knocking, which is found in some plants.

J. C. HAWKINS.

Hyattsville, Md.

CO_2 Recorders for Standby Boilers

Generally, where boilers are operated below rating, heavy heat losses are likely to result. On the other hand, if boilers are crowded or operated considerably above rating during the "off peak" periods, the remaining peak boilers must be kept banked. This, as everyone knows, is most wasteful.

If CO_2 recorders are installed and the firemen are required to carry more than 8 or 10 per cent. CO_2 during the light-load periods, then a larger number of boilers can be operated at a greater net efficiency than is possible by crowding a few and using coal to hold the rest in reserve. This will cause the firemen to regulate the fires as to thickness, as well as regulating the checked draft, keeping in mind that when the damper is closed the door to the coal pile is shut. Without the recorder it is practically impossible to operate boilers under rating without having the fires full of holes. There is always some chance when operating with checked draft and thick fires of having much CO present, but if the CO_2 is reasonably high, one does not need to bother about the CO content.

JOHN F. HURST.

Louisville, Ky.

Pass It On

In connection with your editorial on trade periodicals in the Mar. 24 issue, perhaps your readers would be interested in our system for "passing on" the articles appearing in the trade papers which would be of interest to our organization.

All publications received are carefully looked over by two members of the publicity department and the items of interest marked. These items are then clipped and mounted on a stiff card. After mounting they are finally passed upon by the writer, and such as do not appeal to him as being of interest are so marked and eliminated. The balance are tabulated on the "Week's News" sheet, as in the form herewith.

Copies of this sheet are distributed to everyone in the organization and are returned to the department with a check mark opposite the articles which are wanted. The card carrying the article wanted is checked to indicate to whom it is to go and sent from one to the other.

Finally it is returned to the department and placed on file.

The articles are filed under such general classes as Riveters, Air Compressors, Pneumatic Drills, Hoists, Foundries, Machine Shops, etc.

This system has been successful and saves a great deal of time for the busy man.

THE WEEK'S NEWS

To Mr. A. B. Smith **Date** Sept. 10, 1912

Check	Title and Subject	Paper	Date
	Slides in the Culebra Cut at Panama	Engineering Record	8/31/12
	Seepage in subaqueous railroad tunnels	Engineering Record	8/31/12
	Progress of the Lexington Ave. subway	Engineering Record	8/31/12
	Water	Engineering Record	8/31/12
	Railroads	Engineering Record	8/31/12
	New pneumatic hammer at Panama	Industrial World	8/26/12
	Shaft sinking reversed	Mng. & Scientific Press	8/17/12
	Metallurgy at Bendigo	Mng. & Scientific Press	8/17/12
	Electric motors for mines	Coal Age	8/31/12
	The Colorado River siphon at Yuma, Ariz.	Engineering News	8/29/12
	Coefficients of flow in Manchusett Aqueduct	Engineering News	8/29/12
	Improvements in Pittsburgh's water supply system	Engineering News	8/29/12
	Methods of ventilating railroad tunnels	Engineering News	8/29/12
	Construction and operation of turbo-blowers and compressors	Engineering Magazine	Sept.
	A rope-driven coal cutter	Engineering Magazine	Sept.
	Power machinery of the steel industry	Engineering Magazine	Sept.
	Notes on sand blast	American Machinist	8/29/12
	Drilling charts for iron and steel	American Machinist	9/5/12
	An exhaust-gas turbine	The Engineer	8/23/12
	The rotary drill in the oil fields	Mng. & Eng. World	8/31/12
	Churn-drill examination of placers	Mines & Minerals	Sept.
	Goulds new triplex pumps	Practical Engineer	9/1/12
	New centrifugal pump	Practical Engineer	9/1/12
	Trouble in a pumping plant	Practical Engineer	9/1/12
	Setting up turbines	Practical Engineer	9/1/12
	Tests for packing	Practical Engineer	9/1/12
	Missouri River power station	Power	9/3/12
	Water works of the Kansas Cities	Power	9/3/12
	Power plant of the Kansas City Star	Power	9/3/12
	A National Biscuit Co. plant	Power	9/3/12
	Inspecting and testing electrical apparatus	Power	9/3/12
	Nordberg variable capacity power pump	Power	9/3/12
	Impulse and reaction turbines	Power	9/3/12
	Copper range drill jack and post	Eng. & Mng. Journal	8/31/12
	Stope filing and caving for waste	Eng. & Mng. Journal	8/31/12

The above are on file in the Publicity Dept. Information Bureau and can be had for a limited period on request.
If wanted, please designate by checking opposite article wanted and return to Publicity Dept.

Signed A. B. Smith.

CHARLES A. HIRSCHBERG,
Ingersoll-Rand Co.

New York City.

Alterations to Furnace Prevent Smoke

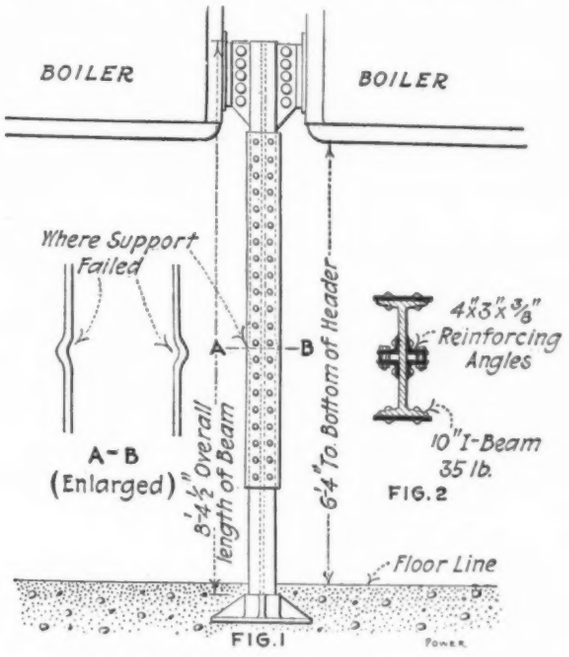
In our endeavor to eliminate smoke, we decided to reconstruct the furnaces under four water-tube boilers, which are arranged in batteries of two. These boilers are served by one stack, independent of the rest of the station, and offer a good chance for observation. The old furnaces are flush with and under the boilers, with front-feed, inclined-grate stokers and a combustion arch. One would think these furnaces should burn the volatile, but when we are required to force the fires, coking takes place further down the grate and much gas is distilled. Before complete combustion takes place the unburned gases have reached the comparatively cool boilers and a dense smoke is emitted from the stack.

After a careful study of conditions, it was decided to give the gases a longer course before they reached the boiler. We, therefore, built an extension to the furnace which brought the grate 3 ft. forward. An arrangement of the arch and other details of more or less importance have brought about the desired results.

While we have not as yet made tests to determine the efficiency of the new over the old furnaces, we have every reason to believe that while we have eliminated smoke we have also increased the furnace efficiency.

We have, however, effected one material saving, where in the old furnaces we lost considerable unburned coal from sifting through the grate and falling into the ash hopper. The new arrangement allows for an extra hopper to catch this fine coal, which amounts to at least a ton a day for each boiler. This saving alone will pay for the improvement.

It was while making these improvements that we discovered what we think a defect in the old furnaces. The



HOW THE SUPPORT WAS REINFORCED

front and side supports are so near the intense heat of the furnace that they failed at a point *AB* in the sketch. We repaired the supports by adding stiffening angles to the web of the I-beam, as shown in Fig. 2. This makes a substantial repair job, and with proper insulation and adequate air ducts it will be a lasting job.

H. R. BLESSING.

Philadelphia, Penn.

Auxiliary Economy in Steam Power Plants

Mr. Carpenter, on page 437 of the Mar. 31 issue, uses arguments against electrically driven auxilaries which are inconsistent with the rest of his article. Electric auxiliaries and bleeding steam from the main units to heat the feed water will show the same saving that more economical steam auxiliaries do if the main unit, noncondensing, can drive them with less steam than steam-driven auxiliaries would take.

Electric auxiliaries would take about 1½ brake horsepower on the turbine shaft for each horsepower delivered to the auxiliary, which would include transmission and motor loss and that would make the water rate 33 lb. per horsepower-hour. A steam-driven auxiliary using 35 lb. of steam per horsepower gives nearly the same economy, and other features, such as price and control, would decide whether it was the most economical

Mr. Carpenter also says: "Even in this case, if steam at boiler pressure can be used in the heating systems, efficient utilization of steam in the pumps, etc., is desirable

as it further minimizes the heat extracted for power." This is clearly a mistake. One horsepower-hour means 2545 B.t.u. extracted for power. If a pump or an engine uses 30 lb. per horsepower-hour, 2545 B.t.u. are taken from 30 lb. of steam. If the engine or the pump uses 60 lb. per horsepower-hour, then 2545 B.t.u. are taken from 60 lb. of steam, but, in any case, 2545 B.t.u. No more, no less.

Radiation from the steam cylinder takes a little more, but radiation on a well covered duplex pump would be as little as on a more economical machine. Efficient pumps and engines are desirable, as during a large part of the year there is exhaust to throw away, but when all the exhaust can be used for heating it makes no difference how much steam per horsepower-hour is used. I doubt if he means, "Also steam at boiler pressure."

HARRY D. EVERETT.

Fort Snelling, Minn.

A Pump-Suction Indicator

A vacuum gage is most useful in connection with pumping installations. Even the smallest plant should have a gage attached to the suction pipe near the pump. Theoretically, the reading multiplied by 13.5 and divided by 12 should give the suction lift in feet. On a new outfit the gage should be calibrated by noting the vertical distance above the water as compared to the calculation from the gage. If it shows a greater vacuum than it should, the difference is due to resistance in the suction pipe or strainer. I have seen a vacuum of 28 in. when the water was 26 ft. vertically from the pump.

Leaks in the suction will cause a variation. After once calibrating the gage to suit the conditions, any trouble, such as stoppage of strainers, etc., can be readily noted by an increased vacuum shown upon the gage.

JOHN F. HURST.

Louisville, Ky.

Direct-Current Fan Motors on Alternating Current

Around many of the older plants will be found a variety of discarded direct-current apparatus. Usually the collection contains a fan motor or two which might be put to good use when the warm weather comes. Any small, direct-current motor may be changed to run on alternating current with a fair degree of efficiency providing its field circuit is of laminated construction.

A direct-current, shunt-wound motor will run when connected to an alternating-current circuit, but it will heat badly and the current will be excessive, due to the phase displacement of the field current by the high reactance of the shunt winding. By placing the shunt winding in series with the armature the motor can be made to run quite satisfactorily.

If one were in possession of data concerning the field ampere-turns, etc., the number of turns for the new winding could be figured easily; but as data are seldom available, it is necessary to use cut-and-try methods.

The writer used 300 turns of No. 26 magnet wire for 12- and 14-in. fan motors with good results. If the speed is too high or the motor heats unduly, more turns should be added, and if the speed is not high enough a few should be cut out. If the motor is provided with a multi-point switch a number of taps may be brought out and so connected that the switch short-circuits more or less of the winding as its position is changed. This will give several speeds without the use of resistance. For these motors, taps were brought out at 300, 350 and 400 turns. The 300-turn tap gave full rated speed and the other two reduced speeds.

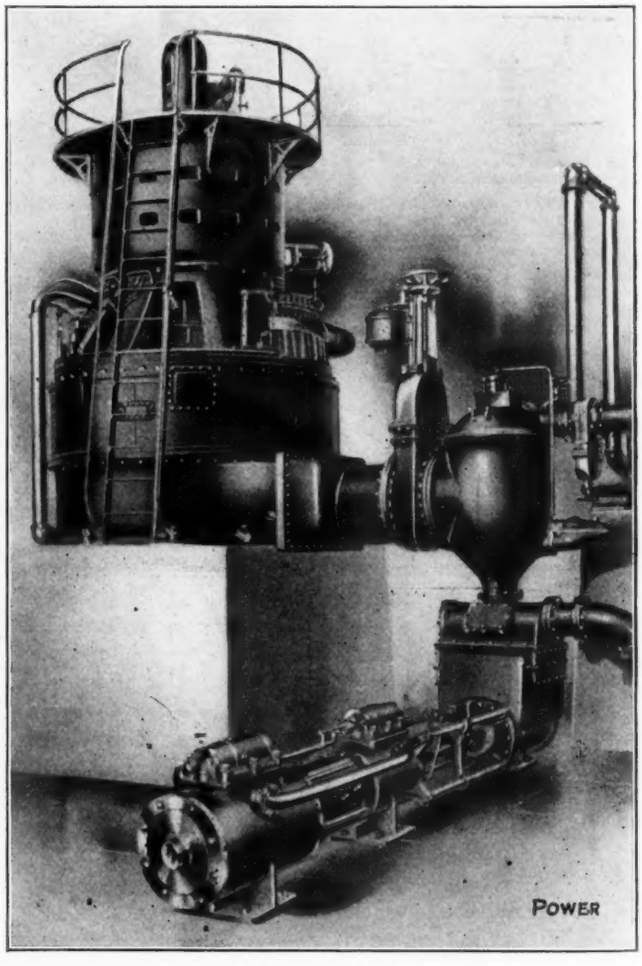
The brushes will spark a trifle, but if the regular brushes are replaced by ones of soft graphite composition the commutator will remain smooth and bright. The motor will be somewhat noisy unless the bearing shells are a good fit on the shaft.

JAMES SPIVENS.

Albuquerque, N. M.

Location of Vacuum-Breaking Mechanisms

John F. Hurst's conclusion as to the location of vacuum-breaking mechanisms on condensing-engine units, in POWER for Mar. 3, suggests a description of a patented vacuum breaker used in connection with steam turbines and similar high-vacuum service.



THE VACUUM BREAKER APPLIED TO A JET CONDENSER

A series of tests having demonstrated the inadequacy of the usual type of float-actuated breaker when dealing with the enormous volumes under high vacuum in turbine work, a type was developed which is dependent upon the difference in absolute pressure on the inside and the

outside of the condenser chamber for its operation. The float chamber, which is on the side of the condenser at the desired high-water level, operates a pilot valve, admitting air to and exhausting it from a cylinder fitted with a piston; in turn, the piston actuates the vacuum-breaker valve proper.

Atmospheric pressure is depended on for the operation of the main valve, which, therefore, may be made of any desired size and standard patterns.

The method of application of this breaker may be made to conform to Mr. Hurst's suggestion, but usually, as the consideration of primary importance is the protection of the prime mover from possible injury by flooding, the breaker is placed on the exhaust line as closely as possible to the prime mover. In some cases, the admission of atmospheric air is directly into the low pressure or exhaust chamber of the turbine. Air being admitted at this point, it is obvious that any water which may have flowed back from the condenser into the exhaust-steam line will be ejected.

From the nature of the mechanism it would be entirely feasible to actuate two or even more breaker valves by means of one float. This would permit the installation of a breaker on the exhaust line next to the prime mover and one on the injection line as well.

The photograph shows the device as applied to a condenser unit. The float box will be noticed on the side of the condenser and the vacuum breaker proper on top of the condenser cap. In this instance, atmospheric air is admitted at this point to insure the safety of the rotative dry-vacuum pump as well as the turbine.

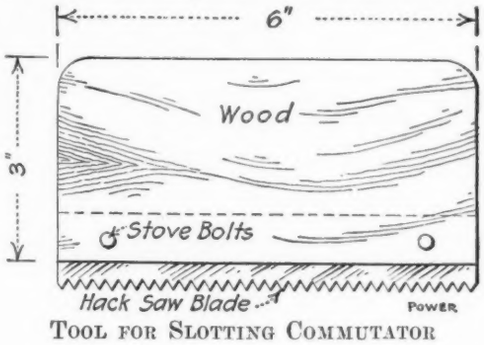
It may be said in connection with the operation of one of these breakers that it opens with a sound like the discharge of a shotgun.

W. M. Fleming.

Holyoke, Mass.

Slotting the Commutator

Referring to Mr. Stark's letter, in the Apr. 7 issue, on undercutting commutator mica, it would seem that if he had examined the motor he would have discovered that the mica was high at first and would have avoided turning it down three times. We have had considerable experience with sparking and have found in most cases



Tool for Slotting Commutator

that it was caused by the brushes being off neutral and not ground to fit the commutator or high mica.

Mr. Stark's method of cutting down the mica is good if the lathe will swing the armature. On large machines the slotting should not be carried too deep as dust will collect between the bars, causing them to throw fire and perhaps produce short-circuits. Also, after a commutator has been slotted it is not good to sandpaper it, as this also allows the sand to collect between the bars with the copper dust and cause flash-overs.

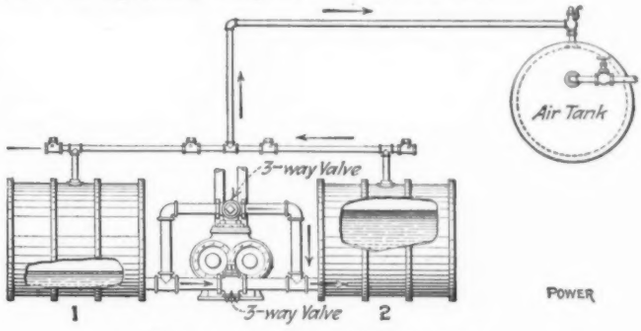
On large machines, Mr. Stark's idea is all right, but it involves baring the engine around for every slot that is cut. A much easier and better way is to make a tool out of a hacksaw blade, putting some tape around one end to form a handle, or making a handle out of wood, as shown in the sketch. To insure a good job, hold a straight piece of iron on the commutator for a guide. The blade can be set to whatever depth it is required to slot.

R. G. Curren, Jr.

Kittanning, Penn.

A Small Air Compressor

We were in urgent need of a small air compressor. An idle steam pump and nearly all the fittings were at hand, so the pump was connected up as shown. Everyone was agreeably surprised at the results.



Pump and Tanks Connected

Any air-tight receptacles, such as oil or plumbers' tanks may be used, but the greater the capacity of Nos. 1 and 2, the fewer the shifts of the three-way valves for a given quantity of air. The capacity of the compressor is equal to its displacement in gallons or cubic feet.

F. W. Hudson.

Ager, Calif.

How a Municipal Station Was Made to Pay

I was interested in Joseph A. Jeckell's article on the above subject in the Mar. 24 issue, page 412, but I fail to see by what method of bookkeeping the plant was considered as paying 13 per cent. on the capital invested.

According to the summary of results given by him, the capital expended amounted to $1,658,200. This money was evidently expended in new plant and equipment, and for this class of machinery it is usual to charge at least 12 per cent. per annum as fixed charges, which, for this amount, is $198,984 per year. The income per year is given as $298,430, from which, subtracting the above fixed charges, leaves only $99,446, which is under 6 per cent. on the amount invested; so the plant is no bonanza as a money-making proposition, but is earning only an ordinary rate of interest.

As a municipal undertaking it is, however, very commendable, for, generally speaking, these enterprises are not as profitable as they should be, owing to lack of efficient methods in the organization.

G. P. Pearce.

Moline, Ill.

Engineers' Study Course

Elementary Mechanics--IX

LAST LESSON'S ANSWERS

36. In the triangle $ADEA$, Fig. 34, draw a line DH from the point D to the center H of the side AE. Also draw AF from A to the center of DE. Assume the triangle made up of a series of strips parallel to the base DE and of the form BC. The *c.g.* of this small strip is at its center S, which by construction lies on the line AF. Hence the *c.g.* of the triangle must lie somewhere on the

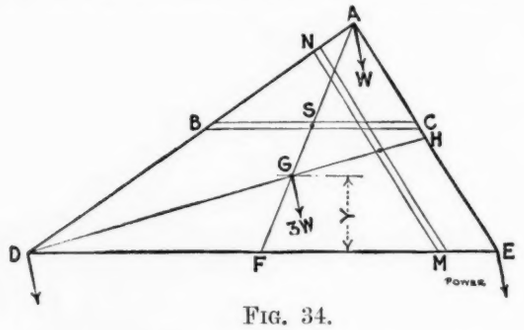


FIG. 34.

line AF. Again, divide the triangle into a series of small strips parallel to the line AE and of the form MN. The *c.g.* of these small strips will fall along the line DH. Therefore, the *c.g.* of the triangle will be at the point of intersection G of the two lines DH and AF.

The *c.g.* might also be found by assuming equal weights W suspended from the vertices A, D and E of the triangle and then taking the moments of these weights about the base of the triangle. The moment arm of the weight W at the point A will be the altitude of the triangle. Let Y equal the distance from the base DE to the *c.g.* located at point G and take moments about the base DE, thus

$$W \times \textit{altitude} = 3 \times W \times Y$$

or

$$Y = \tfrac{1}{3} \textit{ the altitude}$$

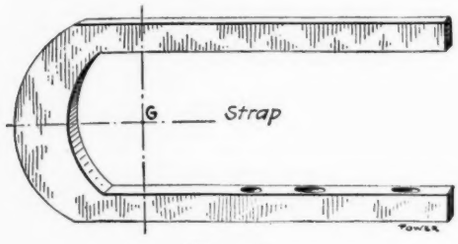


FIG. 35.

Hence *the center of gravity of any triangle is at a distance of one-third the altitude from any and all bases.*

37. Not always; as an example see Fig. 35, which shows the strap of a connecting-rod. The *c.g.* of the strap lies near the point G.

38. Before the plate was punched the *c.g.* was at the point O (see Fig. 36) or at the center of the diagonal AB. The punched plate is symmetrical with respect to the line AB. Assume the *c.g.* at the point G distance X inches from the point O. It can readily be shown that the distance from the point O to the center of the hole C is 2.12 in. The area of the punched plate is $225 - 12.57 = 212.43$ sq.in. The moment about the point O of the *part cut away must equal the moment of the part remaining.* Thus

$$X \times 212.43 = 2.12 \times 12.57$$

or

$$X = \tfrac{1}{8} \textit{ in. (approx.)}$$

39. The weight of a 6-in. cast-iron ball is about 30 lb. and the weight of a 2-in. rod, 18 in. long is 16 lb. The *c.g.* of the rod is 9 in. from the end, and the *c.g.* of the ball is 21 in. from the end, of the rod. Let X equal the

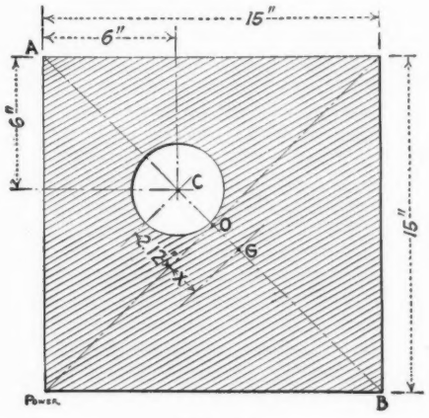


FIG. 36.

distance from the end of the rod to the desired *c.g.* Take moments about the end of the rod, thus

$$9 \times 16 + 21 \times 30 = 46 \times X$$

or

$$46 \times X = 774$$

and

$$X = 16.8+ \textit{ in.}$$

40. The *c.g.* will lie in the vertical axis CY of the frustum, Fig. 37. The *c.g.* of the cone from which the frustum was formed was $\frac{1}{4}$ the altitude (2 in.) from the base EF or at the point B. The *c.g.* of the part of the cone which was cut away, was 1 in. from the base MN. Let the *c.g.* of the frustum $MNFEM$ be located at the point G, X inches from the point B. To find the value of X take moments about the point B.

Thus,

$$16.76 \times 3 = 117.29 \times X$$

or

$$X = 0.43 \textit{ in.}$$

Therefore, the *c.g.* of the frustum $MNFEM$ is on the line CY 1.57 in. from the base EF. (Note—Volume of $MCNM = 16.76$ cu.in.; volume of $MNFEM = 117.29$ cu.in.)

CENTER OF GRAVITY—*Continued*

In problems where the body is symmetrical with neither the vertical nor the horizontal axes the following general method must be applied to find the *c.g.* Assume a given body to be divided into a large number of very small parts, and the weights of each part to be represented by the points w_1, w_2, w_3, etc., as shown in Fig. 38. Locate each of these weights from the axes OX and OY, thus

w_1 is r_1 units from the OY axis, and y_1 units from the OX axis. The resultant of all these small weights will be the total weight W of the given body. Thus $W = w_1 + w_2 + w_3 + \ldots$, etc. This weight or resultant will act at the *c.g.* of the body. Let this point be X units from the OY axis and Y units from the OX axis. Then the distance Y may be found by taking moments about the axis OX. Thus

$$w_1 y_1 + w_2 y_2 + w_3 y_3 + \ldots = (w_1 + w_2 + w_3 + \ldots) Y = WY$$

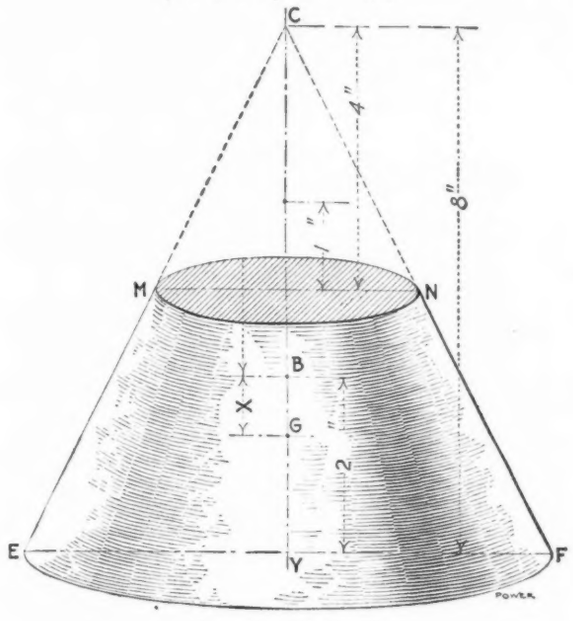


FIG. 37.

$$\text{or} \quad Y = \frac{w_1 y_1 + w_2 y_2 + w_3 y_3 + w_4 y_4 + \ldots}{w_1 + w_2 + w_3 + w_4 + \ldots} \qquad (11)$$

In like manner the value of X may be found by taking moments about the OY axis. Thus,

$$X = \frac{w_1 x_1 + w_2 x_2 + w_3 x_3 + w_4 x_4 + \ldots}{w_1 + w_2 + w_3 + w_4 + \ldots} \qquad (12)$$

If all the weights cannot be located in the plane of the OX and the OY axes, a third reference axis may be used and then,

$$Z = \frac{w_1 z_1 + w_2 z_2 + w_3 z_3 + w_4 z_4 + \ldots}{w_1 + w_2 + w_3 + w_4 + \ldots} \qquad (13)$$

STABLE AND UNSTABLE EQUILIBRIUM

If a slight horizontal force P be applied to the cone shown in Fig. 39 so as to raise the point C, and then if the force P be removed it is evident that the cone will return to its original position. When the force P is removed the weight W forms with the reaction at the point B, a couple which brings the cone back to its former position. If, however, the force P had been applied until the line GW fell outside of the point B, then the cone would have overturned, for in this case the weight W would form with the reaction at the point B a couple which would rotate the cone in a counter-clockwise direction which, of course, would overturn the cone.

Therefore, a body is said to be in stable equilibrium when, if it be slightly displaced from its initial position, the forces acting on the body tend to bring it back to its original position; or the body is in unstable equilibrium if, after being slightly displaced, the forces acting tend to still further move it from its original position.

If, after the body is slightly displaced, the forces are in equilibrium, the body is said to be in neutral equilibrium. Thus in Fig. 39 when the force P is applied, the *c.g.* of the cone rises until the point G is in the same vertical line as the point B, then further application of the force P causes the *c.g.* to be lowered. Assume the cone to be resting on its slant height AB, then any displacement of the body will neither lower nor raise its *c.g.*

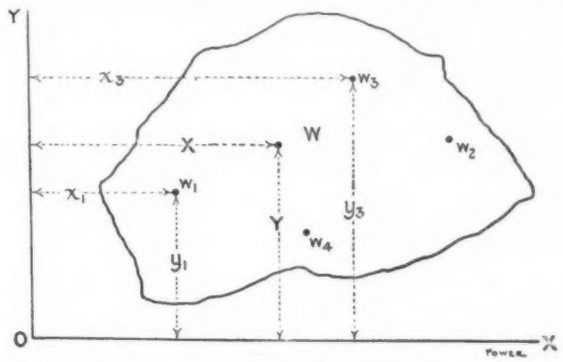


FIG. 38.

Hence the following rule may be applied to test the kind of equilibrium: *If a slight displacement of a body raises its c.g. the body is in stable equilibrium, if the displacement lowers the c.g. the body is in unstable equilibrium, and finally if a slight displacement neither raises nor lowers the c.g. then the body is in neutral equilibrium.*

Still another test is this, if a vertical line drawn through the *c.g.* of the body falls within the plane of support the body is in stable equilibrium and if it falls outside the body is in unstable equilibrium.

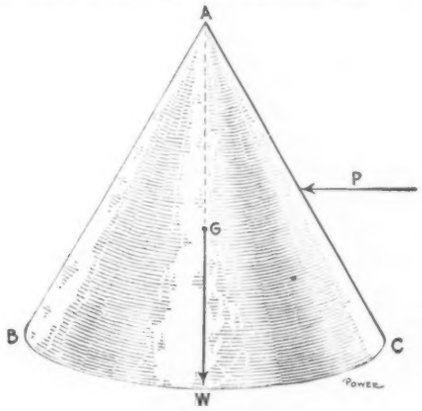


FIG. 39.

Example—A ball resting on the ground is in neutral equilibrium for its *c.g.* remains at a fixed distance from the ground. An engine bed resting on its foundation is in stable equilibrium, for if its *c.g.* be raised the bed will return to its position when the force is removed.

STUDY QUESTIONS

41. The one leg of a standard angle is 6 in. and the other leg is 4 in. If the thickness of the legs is ¾ in., locate the *c.g.* by using equations (11) and (12).

42. In what kind of equilibrium is a horizontal beam which is being raised by a rope attached at its center?

43. Give two illustrations of neutral equilibrium.

44. For the most stable equilibrium, should the *c.g.* of a coal truck be high or low?

45. The drum head of a B. & W. boiler rests on its curved surface. In what kind of equilibrium is it?

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

We thank Brother McEachren, of the bright and useful "Valve World," for his kindly references to "Power." We try to be modest and humble, but being only human, we are pleased by the kindly word and the sincere praise.

P. S.: Of course, this will not prevent our returning a closely written twelve-page "article" digested from old "Power" files to the feller who begins: "OH, HOW I LOVE MY POWER! Please print this at your regular rates." You get this, feller?

⁂

An "Arbeitswillige" is a man who is willing to work, "Coal Age" tells us. It appears to be a Teutonic toning down of those obnoxious epithets "scab" and "rat." We have no quarrel with the first few syllables but "swill"—this is altogether too garbageous! (There's a copyright on this word.—Editor.)

⁂

When there's fighting to be done by our navy folks, everybody takes a hand in it—from the quarter deck down to the stokehole. The daily press is full of Coalpasser Smith's bravery and judgment in an emergency.

⁂

Because the power was off the Hudson & Manhattan system recently for a few minutes, a newspaper wisegink said "an oil-switch jammed the turbine." Awk! and two arfs!

⁂

Here's food in the raw for optimism. The good old wheat crop has reached a billion bushels this year! Of course, rye and corn have done quite well, but we're not particularly interested in them; that is, in the raw. Take this in the "spirit" in which it is given.

⁂

Pure-Fooder Wiley has advanced the best reason yet for the eight-hour law: "It gives men time to do other things besides work." The few power-plant engineers who have heard rumors of the existence of an eight-hour law will please raise their right hands. The "noes" have it.

⁂

"Bugs May Come and Bugs May Go, but Germs Hold On Forever," is the title with a Tennysonian touch of a paper to be read at the American Water Works convention. Might try a half-Nelson or a strangle-hold, or get 'em off their guard with a piece of cheese.

⁂

Hope you read that "Candid Chat" in this issue wherein it is contended that the five-spot you bank today is as big as the hundred you MEAN to save out of next week's earnings. Here's a good argument in its support. In the savings banks of New York state the wage earners have one billion seven hundred and fifty million dollars saved by a little economy and forehandedness.

⁂

THE OLD WOODEN BARROW

(Tune: "The Old Oaken Bucket")

By Billy Spills

How near to our hearts are the scenes of young manhood
When pained recollection presents them to view,
The plant-yard, the coalpile, the wreck of a barrow
That wheeled in the coal. Oh, those days we once knew!
'Twas young we were, strong we were, eager and willing,
But gee! that old barrow did worry us hard.
If pushed straight ahead, the old barrow went sideways,
It tipped up, and rared up, and balked in the yard.

(Chorus)
The old wooden barrow, that busted old barrow,
The barrow we swore we would pitch in the well.

'Twas leaky, and squeaky, had one leg to stand on—
No man could remember it ever had two.
It man-shied, and coal-shied, and skidded and wabbled;
It hit every rock that presented to view;
And always, 'twixt earth and the blue and high heaven
It stopped on the plank—and prepared to depart!
But, brothers, the days of the barrow are over,
So let us join hands and sing out from the heart:

(Chorus)
The old wooden barrow, our lives it did harrow,
But—Here's to the barrow we'd pitch in the well!

Value of Filtered Oil

SYNOPSIS—When properly filtered, oil can be used repeatedly and the tests show that it loses none of its lubricating properties. Excessive filtering surface is unnecessary if efficient precipitation is provided for.

⁂

To determine what deterioration oil suffered from use, a series of comparative tests of used and unused oils was made on different samples of oil at the laboratories of Cornell University. From those tests it may be concluded that if oil is properly filtered, it can be used repeatedly without losing any of its lubricating qualities.

Data secured from tests of oils used at the power plant of the Hotel McAlpin, New York City, are here selected as representing severe operating conditions.

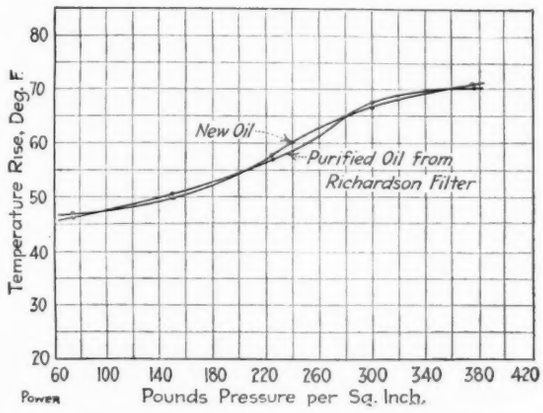


FIG. 1. TEMPERATURES OF BEARING ABOVE ROOM TEMPERATURES

This plant is equipped with an oiling and filtering system which supplies flooded lubrication to four Corliss engines, three air compressors and one crank-and-flywheel pump having a total of 134 points of lubrication. The plant operates 20 hours per day, and the average temperature of the engine room is 100 deg. F. On account of the great variety of machines lubricated, the high load factor and the exceptional temperature conditions, the work is probably representative of average power-plant conditions. The oil was a good grade of mineral engine oil.

Observations showed that the average amount of oil handled by the lubricating system was 150 gal. per hour, or 3600 gal. per day, which is equivalent to 1800 barrels per month. Although this amount of oil is continuously supplied to the bearings, only three barrels of oil per month are added to the system. Even this cannot be charged to natural shrinkage in the system, as large quantities of oil are drawn off from the filters and used in cans for hand-oiling of small pumps, valve gears and bearings not connected to the oiling system.

To determine the changes undergone by the oil, a sample of the new oil as received in barrels from the manufacturers was secured and also a sample of the oil drawn off from the clean oil compartment of the filter. These samples were sealed and shipped to the testing department at Cornell University, and subjected to a series of tests under the supervision of Professors Carpenter and Sawdon, the results of which tests are given in the accompanying tables and curves.

A series of friction tests were made on a Thurston railroad lubricant tester, having a hardened-steel journal and bronze bearings with a total area of 20 square inches. In all tests the machine was run at a constant speed of about 360 r.p.m. and the load applied in increments of 1500 pounds total pressure or 75 pounds per square inch. The test at each load was continued until the friction and temperature of the bearings had become constant. The oil was fed upon the

TABLE 1. SAMPLE "A," NEW OIL

Press. on bearing, total lb.	1500	3000	4500	6000	7500
Press. on bearing, lb. per sq.in.	75	150	225	300	375
Duration of test, min.	120	50	60	60	50
Temperature of bearing, max.	114.5	120.0	129.5	139.0	143.5
Temperature of room, aver.	68.2	70.7	71.5	72.5	73.0
Diff. in temp. bearing and room	46.3	49.3	58.0	66.5	70.5
Rate of feed, drops per min. aver.	34.8	38.4	33.6	37.0	38.2
Speed, r.p.m.	362	361	361	361	359
Speed, ft. per min.	355	354	354	354	352
Minimum coeff. of friction	0.01166	0.00666	0.00533	0.00458	0.00373

side of the bearing through a sight-feed oiler and the feed maintained as nearly constant as possible throughout all the tests. Readings made at ten-minute intervals are summarized in tables 1 and 2.

The coefficients of friction shown in Tables 1 and 2 represent the lowest value found for each load; that is, as soon as a given load is applied the coefficient at first high, gradually falls off until it becomes practically constant. This latter coefficient corresponds to those shown in the tables and represents the values that would obtain in ordinary practice where engines operate continuously for more than an hour. The temperature readings given in the tables are the highest reached for each load, that is, as each new load is applied, the bearing gradually heats up until the temperature becomes practically constant.

The differences in temperature between the bearing and the room have been plotted in the curves shown in Fig. 1. Curves showing the coefficients of friction of the new and filtered oil are shown in Fig. 2.

TABLE 2. SAMPLE "B," FILTERED OIL

Press. on bearing, total lb.	1500	3000	4500	6000	7500
Press. on bearing, lb. per sq.in.	75	150	225	300	375
Duration of test, min.	150	60	60	80	50
Temperature of bearing, max.	120	125.5	132.5	144.5	147.2
Temperature of room, aver.	74	74.8	75.3	77.0	77.5
Diff. in temp. bearing and room	46	50.7	57.2	67.5	69.7
Rate of feed, drops per min. aver.	38.9	40.3	37.4	40.5	41.4
Speed, r.p.m.	363	363	360	361	358
Speed, ft. per min.	356	356	353	354	351
Minimum coeff. of friction	0.01265	0.00717	0.00522	0.00458	0.00367

The question naturally arises, what physical changes if any, has the oil undergone during this extended period?

The results of tests made to determine this are given in Tables 3 and 4:

TABLE 3. PHYSICAL PROPERTIES, SAMPLE "A," NEW OIL

Color: medium red, translucent.
Flash point: 410° (open cup).
Burning point: 460° F. (open cup).
Specific gravity at 60° F. water as 1 = 0.895.
Viscosity (with Olsen viscosimeter).
Water as 1 at 60° F. Time 27.9 secs. for 100 cc.

Temperature F.	Time 100 cc. Secs.	Relative Viscosity
70	97.6	3.48
70	96.6	3.46
71	96.2	3.45
97	59.8	2.14
94	61.8	2.21
130	45.6	1.63
132	43.8	1.57
214	34.0	1.22
215	34.2	1.225

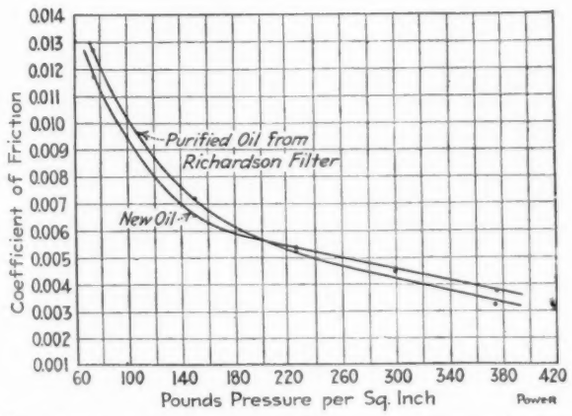


FIG. 2. COEFFICIENTS OF FRICTION WITH VARIOUS BEARING PRESSURES

TABLE 4. PHYSICAL PROPERTIES, SAMPLE "B," FILTERED OIL

Color: very dark red, opaque.
Flash point: 410° F. (open cup).
Burning point: 440° F. (open cup).
Specific gravity at 60° F. water as 1 = 0.903.
Viscosity (with Olsen viscosimeter).
Water as 1 at 60° F. time 27.9 secs. for 100 cc.

Temperature F.	Time for 100 cc. Secs.	Relative Viscosity
68.0	138.0	4.94
69.0	134.0	4.80
70.0	130.2	4.66
103.0	60.4	2.16
114.0	50.6	1.81
130.0	45.2	1.62
152.0	39.0	1.40
147.5	40.2	1.44
218.0	33.2	1.19

The viscosity readings are shown plotted in Fig. 3.

From comparison of the tables it would appear that the use of the oil increased its specific gravity. This is to be expected as the oil, in passing through the bearings, has had some of its more volatile constituents driven off; also, because a small quantity of cylinder oil used for lubricating the piston rods and stuffing boxes finds its way into the oiling system. The viscosity curves also confirm this hypothesis as the tests show that the used oil has a higher viscosity than the new, demonstrating that as oil is used over and over in an oiling system it actually gains in body, provided, of course, the filter thoroughly removes entrained water.

The results of the friction tests shown in Fig. 3 are also consistent with these physical changes, and it is to be noted

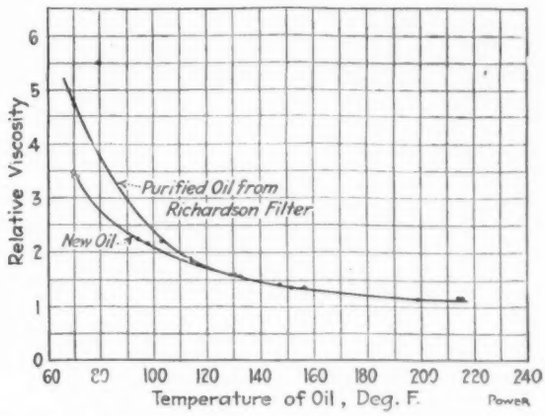


FIG. 3. RELATIVE VISCOSITY, NEW VS. PURIFIED OIL

that the new oil shows a slightly lower coefficient of friction on low bearing pressures. This may be because the old oil, having more body, is better able to maintain a lubricating film when subjected to higher pressures. The difference between these two curves is so slight that, for all practical purposes, it may be concluded that under average operating conditions properly filtered oil is quite as good a lubricant as new oil.

The curves shown in Fig. 1, are probably the ones that will be most interesting to the operating engineer, as it is usually by the temperature of the bearings that he determines the condition of lubrication. It may be noted that these curves are practically superimposed and in no case is the variation more than a few degrees, indicating, from temperature rise, that properly filtered oil should be as good as new oil.

The above data was furnished by the engineering department of the Richardson-Phenix Co., lubrication engineers and manufacturers, Milwaukee, Wis.

Explosion of a "Safety" Water-Tube Boiler

The photographs herein reproduced are the best we have been able to secure showing the wrecked boiler and surrounding buildings at the Drummond Collieries at Westville, N. S., brief mention of which appeared May 5, on page 652.

Fig. 1 is a general view of the wrecked boiler house; A shows the position of the boiler before the explosion; B, the relative position of the larger part of the boiler after the explosion, and C the building through which the front head and water leg went. Figs 2 and 3 are views of the same part of the rear portion B of the boiler from different angles. Fig. 4 shows one of the remaining boilers.

From the reports at hand it appears that the longitudinal seam on the front course of the steam drum failed throughout its length. This sheet straightened out almost flat, tearing entirely away from the front head and water leg, and also at the circumferential seam joining it to the second course, leaving the boiler proper in four parts, viz., the rear water leg and two courses of plates attached (which were hurled 140 ft. from its setting); the front sheet; the front water leg and the front head which separated and were thrown about 100 ft. in the opposite direction.

The shell was 48 in. in diameter by 19 ft. 5 in. long, and was made of ½-in. plates. There were 116 four-inch tubes. The boiler was not insured nor subject to other inspection. The coroner's inquest brought out the following statements:

F. G. Murphy, mining engineer, instructor at the Technical College, Halifax, gave the result of his test of the plate, as to its ductility. The maximum load was 65,970 lb., and the

FIG. 1. GENERAL VIEW OF SURROUNDINGS

FIG. 2. REAR SECTION

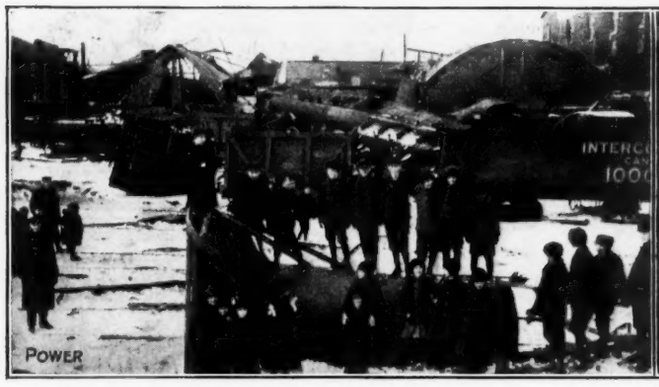


FIG. 3. SAME SECTION AS FIG. 2.

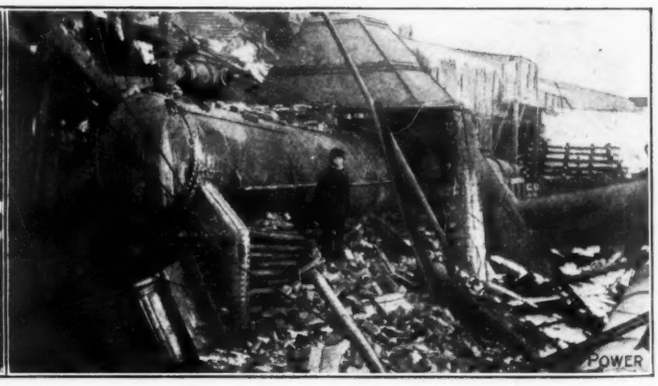


FIG. 4. ADJOINING BOILER

yield point was 57,930 lb., which acted more like a high-carbon steel than a mild boiler steel, the yield point of which should be about 33,000 lb. His chemical test showed carbon, 0.15; phosphorus, 0.055; sulphur, 0.049; manganese, 0.61.

T. W. Hardy, analytical chemist, Nova Scotia Steel Co., said his test showed carbon, 0.16; phosphorus, 0.058; sulphur, 0.047, and manganese, 0.64. A physical test gave elastic limit, 44,220 lb.; the breaking strain, 64,979 lb.; elongation, 18.62 per cent.; reduction, 45.51 per cent.

William Macfarlane, New Glasgow, foreman boiler maker for I. Matheson & Co., said when asked as to the cause of the explosion: "I found that the boiler gave at the longitudinal seam. So far as I could see, it was a crack in the making; that the plate was cracked in the rolling, just the skin of the plate; there would be no way of seeing it; the contraction and expansion would make it worse."

W. G. Matheson said: "I would not use it. In proper samples, the carbon runs from 0.18 down to 0.14, so you see 0.16 is a fair average. The phosphorous should run from 0.029 to 0.010. There is a good deal of difference between this and 0.047, which is what the sample from the exploded boiler gives.

"Sulphur should run from 0.039 to 0.026. We want the limit to be 0.035, although a little higher does not do much harm provided the phosphorus is low.

"Manganese should run from 0.43 at the highest to 0.35; we want to see it under 0.60. Boiler plates having such percentages of phosphorus, sulphur and manganese would be too high, as shown, in the elastic limit, which runs up to 44,220 lb., according to our test." He thought that the crack caused the explosion, and that the cause of the crack was the brittle plate.

Gasoline-Electric Locomotive — A petrol-electric locomotive crane has recently been constructed in Germany at the Aktiengesellschaft Lauchhammer at Lauchhammer. The motive power is furnished by a 40-hp. petrol engine coupled direct to a continuous-current dynamo having a capacity of 23 kw. at 230 volts. The machine runs on eight standard-gage wheels, each of the inner axles being driven by a 12½-hp. electric motor through bevel-reducing gear. The rotating crane has a capacity of two tons and a radius of action of 32 ft., the cable drum being operated by an 8-hp. motor.

Errata—In the article on "Refrigeration Plant Troubles and Remedies" in the May 5 issue, line 14, first column, page 634, should read: Thus we need 126 × 3.6 = 453 lb. of new aqua ammonia of 26 deg. density.